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TABLE OF CONTENTS

Vol. 20 October, 1937 No. 10

THE JOURNAL

Controlled Boiling Acid Test for Porcelain Enamels 317
By E. E. Bryant

Effect of Manganese, Nickel, and Cobalt Oxide upon the Adherence and Reboiling Properties of a Ground-Coat Enamel 319
By E. E. Howe and R. L. Fellows

Surface Tension of Various Molten Glasses 325
By A. E. Badger, C. W. Parmelee, and A. E. Williams

Concerning the Strength of the Weakest Bottles 329
By F. W. Preston

Effect of Iron and Its Compounds on Color and Properties of Ceramic Engobes and Materials 336
By T. N. McVay and C. W. Parmelee

Influence of Compositions of Undersips, Glazes, and Bodies on Blistering and Other Glaze Defects 344
By H. G. Schurecht and J. F. McMahon

Evaporation by Submerged Combustion: VI, Dewatering Clay Suspensions 348
By K. A. Kobe, Hewitt Wilson, and T. M. Sheehy

CERAMIC ABSTRACTS

16—10

Abrasives 291
Art and Archeology 293
Cements 295
Enamel 295
Glass 297
Structural Clay Products 303
Refractories 303
Terra Cotta 306
Whiteware 306
Equipment and Apparatus 307
Kilns, Furnaces, Fuels, and Combustion 308
Geology 309
Chemistry and Physics 311
General 315

Henry Le Chatelier: II, His Publications 316
By Alexander Silverman

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A CONTROLLED BOILING ACID TEST FOR PORCELAIN ENAMELS*

By E. E. Bryant

Abstract

The apparatus described in this paper was designed to accomplish certain results for boiling acid-resistance tests as follows: (1) temperature control of the acid solution; (2) constant volume of the acid solution by eliminating evaporation; (3) confinement of the acid attack to a definite area of surface; (4) acid solution unweakened by attack on surfaces not pertinent to the test; and (5) a weighed sample may be used to determine the weight of enamel removed by acid attack, or loss of gloss may be determined. Data are included to show the accuracy and general possibilities of the test.

I. Description of the Apparatus

The apparatus consists of a reflux condenser in the top of a bell jar. The inside diameter of the bell jar should be about $2^1/_2$ inches. A rubber gasket is cut to fit under the bottom of the bell jar. By using an iron plate under the enamel sample, a clamp may be made to hold the bell jar down on the enamel. The rubber gasket between the two forms a water-tight joint (see Fig. 1).

The bell jar may be made by cutting the bottom from a suitable chemical bottle.

II. Samples for the Test

Any flat area of enamel may be used for a sample to determine loss of gloss or etching. The most convenient sample is a 4- by 12-inch sheet.

A sample weighing less than 75 grams is recommended for loss-of-weight determinations. A disk or an octagon measuring about $3^1/_4$ inches across is preferred.

III. Acid Solutions for the Test

A $2^1/_2\%$ solution of malic acid was used for tests with this apparatus. Resistance to any acid, however, may be determined in the same manner.

IV. Operation of the Test

A sample on which the gloss reading[1] or the weight has been taken is set up in the apparatus. Two hundred milliliters of acid solution are poured into the apparatus through the reflux condenser and the iron plate is heated rapidly. After the acid solution begins to boil, the heat may be reduced so that no vapor is expelled from the reflux condenser.

The timing for this test starts when the acid is placed in the apparatus. At the end of the test time, the acid solution is removed and the apparatus is rinsed free of acid. The recommended time for this test is 30 minutes.

After the test, the gloss reading or weight is again taken to determine the degree of acid attack.

The weight loss per square inch should be used to compare weight results from two different bell jars.

V. Accuracy and Possibilities of the Test

A $2^1/_2\%$ solution of malic acid was used for all tests.

A Hunter gloss comparator[1b] was used to take gloss readings for all tests. The gloss readings are based on a comparison of sharpness of image.

(1) Loss of Gloss Method[2]

Four 4- by 12-inch samples of a commercial acid-resistant enamel were used for these tests, and a 30-minute controlled boiling acid test was run on one end of each of the samples. The other end of each sample was tested by boiling for 30 minutes in an open beaker with the ground coat on the back of the sheet exposed to the acid.

A 25-minute controlled boiling acid test was then run at the center of each sample.

The results of these tests are given in Table I.

(2) Discussion of Results in Table I

The percentage loss of gloss is the percentage of the original gloss which is lost due to acid attack. By comparing the results of the three tests, it will be noted that the controlled boiling acid test is more severe than an open boiling acid test.

---

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Enamel Division).

[1] (*a*) "Gloss Comparator," *Nat. Varnish & Lacquer Assn. Circ.*, No. 493 (Oct., 1935).

(*b*) R. S. Hunter, "Methods of Determining Gloss," *Jour. Research Nat. Bur. Stand.*, **18** [1] 19–39 (1937); *Ceram. Abs.*, **16** [4] 107 (1937).

[2] By permission, W. N. Harrison, Bureau of Standards. See *Nat. Bur. Stand. Tech. News Bull.*, No. 232 (Aug., 1936).

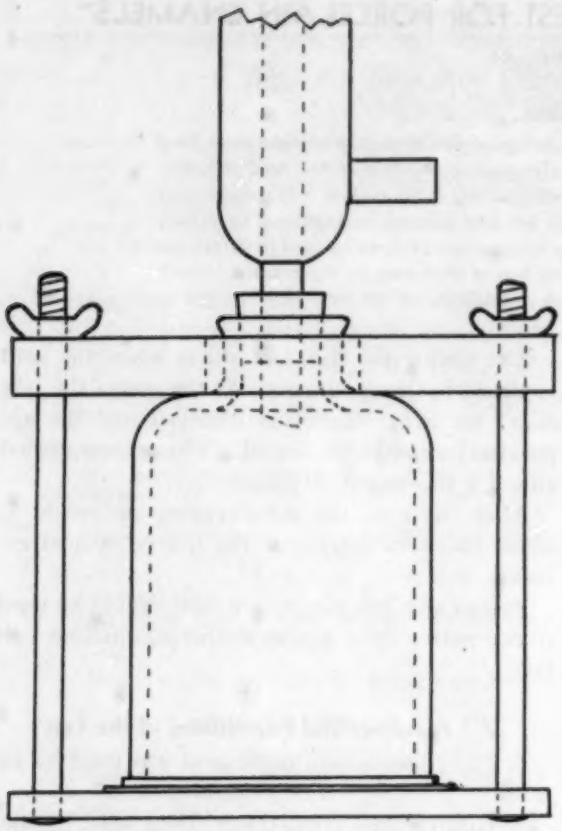

FIG. 1.—Apparatus for controlled boiling acid tests.

(3) Loss-of-Weight Method and Comparison with Loss of Gloss

Octagon-shaped samples were used for these tests. The area exposed to acid attack was 5.41 square inches. Two samples each of six acid-resistant enamels and one nonacid-resistant enamel were tested with the 30-minute controlled boiling acid test.

TABLE I

RESULTS OF VARIED TESTS ON A COMMERCIAL ENAMEL

	Sample No. 1	2	3	4	Av. of 4
30-minute controlled boiling acid test					
Original gloss	85	85	87	86	
Gloss after test	63	64	67	65	
Loss of gloss	22	21	20	21	
Loss of gloss (%)	26.0	24.5	23.0	24.5	24.5
30-minute open boiling acid test					
Original gloss	85	86	88	87	
Gloss after test	67	69	70	67	
Loss of gloss	18	17	18	20	
Loss of gloss (%)	21.0	20.0	20.5	23.0	21.0
25-minute controlled boiling acid test					
Original gloss	85	85	87	86	
Gloss after test	66	67	70	68	
Loss of gloss	19	18	17	18	
Loss of gloss (%)	22.5	21.0	19.5	21.0	21.0

Loss of gloss and loss of weight were determined. The results are given in Table II.

(4) Discussion of Results in Table II

The loss-of-gloss method gives good comparisons for degree of acid attack as indicated by surface destruction.

The loss-of-weight method indicates the amount of material dissolved. This is a quantitative term for the amount of chemical reaction which takes place. A comparison of the loss-of-weight results from two samples of the same enamel should in-

TABLE II

RESULTS OF CONTROLLED BOILING ACID TEST ON SIX ACID-RESISTING ENAMELS AND ONE NONACID-RESISTING ENAMEL

Enamel No.	Sample	Original gloss	Gloss after test	Loss of gloss	Loss of gloss (%)	Original weight	Weight after test	Loss of weight
1	A	96	85	11	11.5	69.2787	69.2755	0.0032
	B	95	85	10	10.5	66.4084	66.4051	.0033
	Av.				11.0			.0032
2	A	86	78	8	9.5	69.1017	69.0985	.0032
	B	87	78	9	10.5	67.6128	67.6095	.0033
	Av.				10.0			.0032
3	A	94	84	10	10.5	68.4709	68.4666	.0043
	B	92	84	8	8.5	68.2562	68.2520	.0042
	Av.				9.5			.0042
4	A	85	68	17	20.0	45.1674	45.1631	.0043
	B	82	66	16	19.5	45.4245	45.4201	.0044
	Av.				20.0			.0043
5	A	84	75	9	10.0	52.8835	52.8812	.0023
	B	82	74	8	10.0	51.6731	51.6705	.0026
	Av.				10.0			.0024
6	A	80	66	14	17.5	46.4240	46.4201	.0039
	B	76	63	13	17.0	48.3923	48.3879	.0044
	Av.				17.0			.0041
7*	A	75				46.6448	46.5762	.0686
	B	73				48.2399	48.1712	.0687
	Av.							.0686

* Nonacid-resisting enamel.

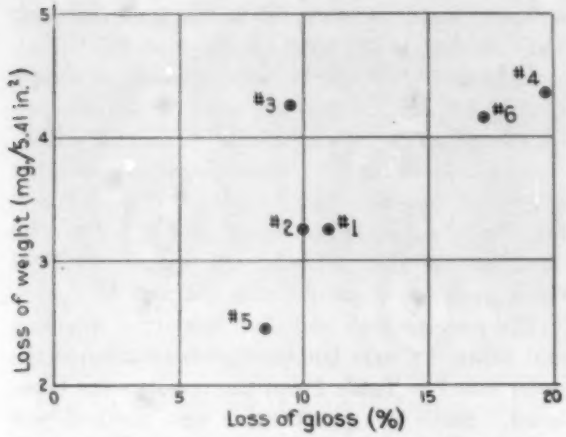

FIG. 2.—Six enamels of various compositions from Table II.

dicate, therefore, how accurately this apparatus controls the tests. The greatest variation of results for two samples of the same enamel is 12% of the loss in weight. Owing to laboratory routine, the original and final weighings were independently made by different operators so that no anticipation of results occurred.

The wide variation of loss of weight between acid-resistant enamels and nonacid-resistant enamel No. 7 indicates that relative acid resistance of nonacid-resistant enamels could be determined by loss of weight.

For a comparison of loss of gloss with loss of weight, a graph was made (Fig. 2). The average results for each acid-resistant enamel in Table II were used. A definite curve cannot be produced by plotting percentage loss of gloss against loss of weight. This indicates that there is no direct relationship between loss of gloss and loss of weight from acid attack; that is, an enamel would not have the same rating by both methods.

VI. Conclusions

This controlled boiling acid test for porcelain enamel gives reproducible results either by the loss-of-weight or the loss-of-gloss methods.

There is no direct relationship between the loss-of-gloss and the loss-of-weight methods which will hold for all enamels. The intended use of the enamel should determine the method to be used for testing.

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EFFECT OF MANGANESE, NICKEL, AND COBALT OXIDE UPON THE ADHERENCE AND REBOILING PROPERTIES OF A GROUND-COAT ENAMEL*

BY E. E. HOWE AND R. L. FELLOWS

ABSTRACT

A series of enamels was compounded in which small amounts of adherence-promoting oxides were varied and their effect upon the adherence and reboiling properties of a base enamel glass applied to steel was studied. Results indicated that cobalt oxide was necessary in producing adherence, whereas nickel and manganese oxides increased the firing range. Reboiling was found to be dependent upon adherence. Photomicrographs showed that different phases existed in the interfacial layer when the different metallic oxides were introduced into the enamel.

I. Introduction

In a study to find the basis for use of the present combination of metallic oxides in production today and their relation to the adherence and reboiling tendencies, a series of enamels was compounded in which small amounts of manganese, nickel, and cobalt oxides, within the range of commercial enamels, were introduced separately and in combination to a base enamel glass. The fritted enamels were milled, applied to steel, and then fired at varying temperatures for a fixed time interval. Adherence of the enamel to the metal, reboiling tendency, and microscopical tests were made.

II. Experimental

The oxides of manganese, nickel, and cobalt in amounts as shown in Table I were incorporated in a base enamel glass of the following composition:

SiO_2	51.37%	B_2O_3	17.55%
Al_2O_3	5.32	MnO	
CaF_2	6.72	NiO	
Na_2O	15.87	CoO	
K_2O	3.17		

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Enamel Division).

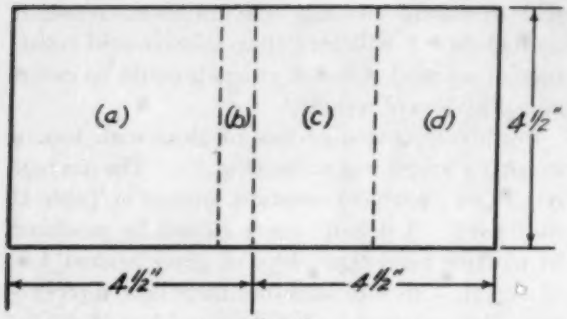

FIG. 1.

Seventeen different compositions of 100 pounds each were carefully smelted in a gas-fired box-type smelter and then quenched in water.

Fifty ounces of each frit in the dry state was milled along with the following additions: frit 100, Vallendar clay 7, borax $^3/_4$, and water 45 parts. The enamels were milled to a fineness of 12 to 15 grams dry residue on a 200-mesh sieve.[1]

To obtain as uniform steel conditions as possible, all of the samples were cut from the same sheet of 20-gage enameling stock from which a 3-inch margin had been sheared to eliminate variations from possible differences in the edge of the sheet. The size of each panel measured $4^1/_2$ by 9 inches. As each panel was sheared from the sheet, it was numbered with a steel die so that a record could be kept of the position from which any certain sample was obtained.

The sample plates received the usual alkaline cleaning, hot sulfuric acid pickling, and alkaline neutralizing treatment without the use of nickel flashing. All of the panels were set in the same basket, thus receiving identical treatment. The pickled samples were weighed on a torsion balance accurate to $^1/_2$ gram and the weights were recorded.

After the milled enamels had aged for 24 hours, they were so adjusted to dip 37 to 39 grams per square foot. The dry weight of enamel was determined upon each dipped sample, and none showed a variation of more than $1^1/_2$ grams in weight of application. Six panels were prepared in this manner from each of the enamels, and care was taken to insure that the face side of the panel corresponded to a selected side on the sheet.

Seventeen panels, comprising one of each enamel composition, were fired at the same time upon hot firing tools in an electrically controlled (26- by 48-inch) box-type electric furnace for four minutes each at the following temperatures: 1500°, 1520°, 1540°, 1560°, 1580°, and 1600° F.

After firing, the panels were sheared as shown in Fig. 1. Section (*a*) was tested for adherence by means of a falling-weight impact machine, section (*b*) was used for microscopic cross-section study, section (*c*) was given the standard reboil fire after the panels had stood around for several days, and section (*d*) was reserved for possible check upon some questionable sample.

The panels which had been tested for reboiling and adherence were laid out for observation in the order listed in Table I and the results were tabulated. Since no quantitative test method was available, values were given for plates of low adherence and reboiling, and an increase of these properties was denoted by a larger number. Although exact data are not obtained by this means, comparative values are obtained which indicate a trend.

The panels which had been fired at 1560°F, the proper maturing temperature for this enamel, were selected for the microscopic cross-section study. Samples about $^1/_2$-inch square were mounted in alloy and polished for microscopic examination. The photomicrographs shown were obtained from these sections.

Two of the milled enamels were dried, powdered, and fused down, and samples suitable for use in the interferometer were prepared. The thermal expansion was then determined on these two enamels.

III. Results

The effect of the cobalt, nickel, and manganese oxide additions upon the adherence and reboiling tendencies is shown in Table I. The figures in Roman numerals denote the adherence values and the figures in Arabic numbers denote the reboiling values. Figure 2 shows the appearance of the

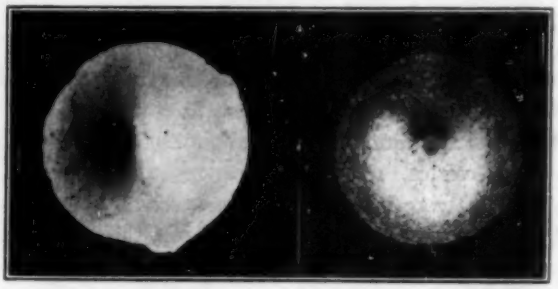

FIG. 2.—Photographs showing appearance of two panels after being tested for adherence. *Left*, adherence 0; *right*, adherence IV.

[1] Determined by the Standard Method of the Enamel Division of the American Ceramic Society.

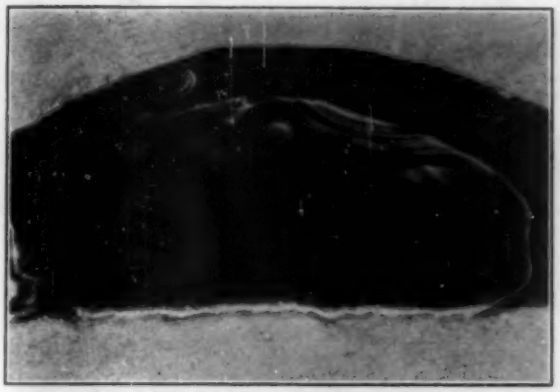

FIG. 3.—Cross-section of a reboil bubble. ×350.

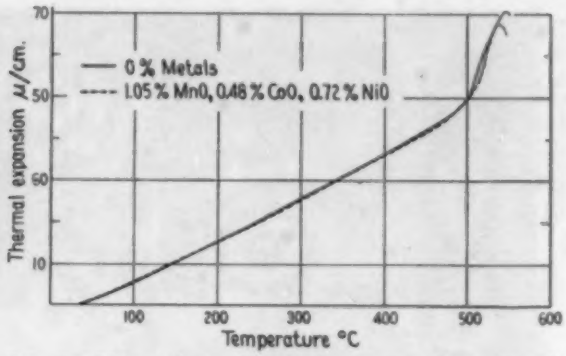

FIG. 4.—Linear thermal expansion curves of an enamel, with and without metallic oxides.

spot on the panels tested by the falling-weight impact machine and indicates the basis for the adherence values given in Table I. The reboiled panels were difficult to photograph so as to bring out the differences in amounts on each and therefore are not shown.

Figure 3 was made of a cross-section through a reboil bubble at about the peak of its development and, because these bubbles all seem to develop almost simultaneously, by removing the sample from the furnace in the second fire when the bubbles rise on the surface of the enamel, a conception of the amount of reboiling was obtained. The time required for each sample to reach this condition was about 25 seconds. This time value was the same for each panel tested.

The series of photomicrographs, Figs. 5 to 10, inclusive, taken at a magnification of one thousand diameters, with bright and dark field illumination, show the nature of the enamel-iron interface of the different enamel compositions fired on steel at 1560° for 4 minutes. The photomicrographs

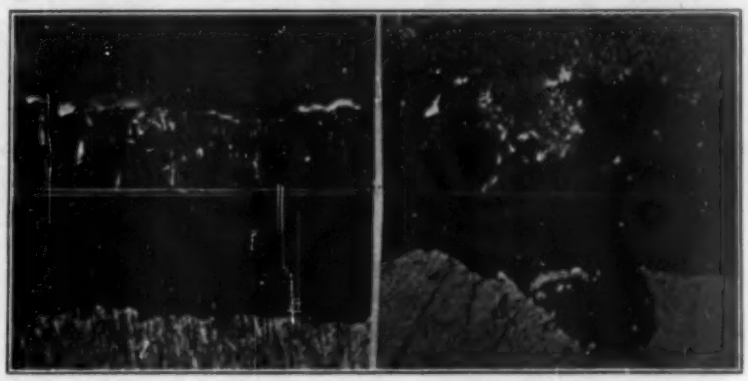

FIG. 5.—*Left*, 0% metals; *right*, 1.05% MnO.

TABLE I

TABLE OF COMPOSITIONS SHOWING EFFECT OF MANGANESE, COBALT, AND NICKEL OXIDES ON ADHERENCE AND REBOILING TENDENCIES AT DIFFERENT TEMPERATURES

Temp. °F																	
1500	0 0	I 1	II 2	IV 2	0 1	0 1	0 2	0 1	I 2	I 1	IV 3	0 1	0 1	I 2	III 2	IV 2	IV 2
1520	0 0	I 1	II 2	IV 2	0 1	0 1	0 2	0 1	I 2	III 2	IV 3	0 1	0 1	I 2	III 2	IV 2	V 3
1540	0 0	I 1	III 3	IV 3	0 1	0 2	I 2	0 1	I 2	III 2	IV 3	0 1	0 1	I 2	IV 3	IV 2	V 3
1560	0 0	I 1	III 3	IV 3	0 1	0 2	I 3	0 2	I 2	III 3	IV 3	0 1	0 2	I 3	IV 4	IV 3	V 4
1580	0 0	I 1	III 3	IV 4	0 1	0 2	I 3	0 2	I 1	III 3	IV 4	0 1	0 2	I 3	IV 4	IV 3	V 4
1600	0 0	I 1	III 3	IV 4	0 1	0 2	I 3	0 2	I 1	III 3	IV 4	0 1	0 2	I 3	IV 4	IV 4	V 5
% CoO		0.24	0.48	0.72					0.24	0.48	0.72				0.48	0.48	0.48
% NiO					0.24	0.48	0.72					0.24	0.48	0.72	0.24	0.48	0.72
% MnO								1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

NOTE: Figures in Roman numerals denote adherence; those in Arabic denote reboiling.

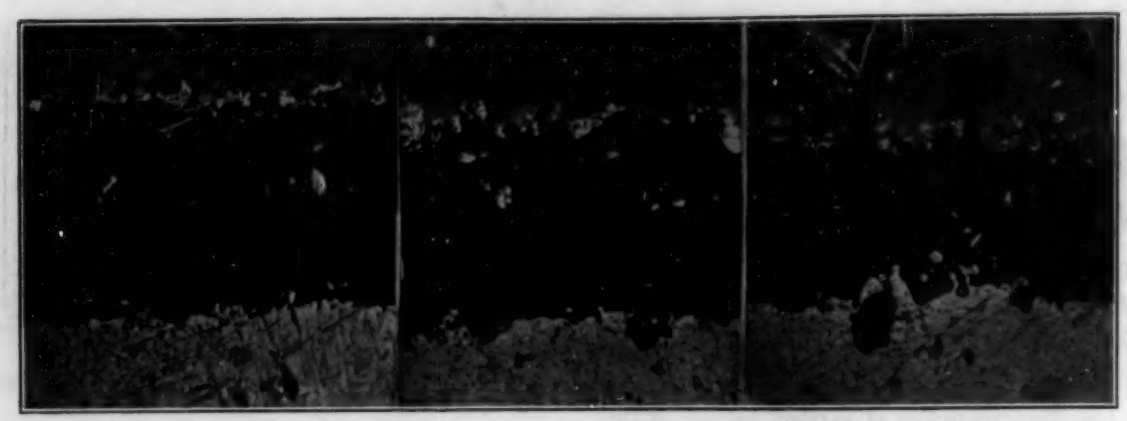

FIG. 6.—*Left*, 0.24% CoO; *middle*, 0.48% CoO; *right*, 0.72% CoO.

FIG. 7.—*Left*, 0.24% NiO; *middle*, 0.48% NiO; *right*, 0.72% NiO.

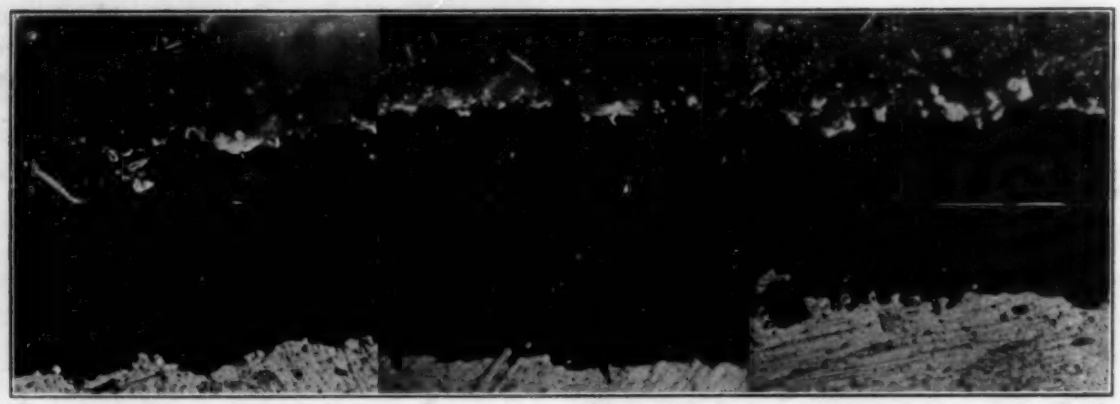

FIG. 8.—*Left*, 1.05% MnO, 0.24% CoO; *middle*, 1.05% MnO, 0.48% CoO; *right*, 1.05% MnO, 0.72% CoO.

were made on the samples before they were etched.

The sections were etched with a solution of dilute hydrochloric acid in alcohol, which gave comparable results to alcoholic stannous-chloride etching solution. This etchant, which is supposed to be a preferential solvent for ferrous oxide, gave results that indicated the presence of ferrous oxide in all of the samples. The sections after etching were not photographed.

Two linear thermal expansion curves of enamel,

one with 1.05% MnO, 0.48% CoO, and 0.72% NiO and one without any metals, are shown in Fig. 4.

IV. Discussion of Results

A study of the results in Table I indicates that (1) practically no adherence was obtained unless cobalt was present in the enamel glass; (2) the reboiling tendency of the enamel increased when the adherence of the enamel increased and no one metallic oxide promoted reboiling more than another; and (3) the addition of manganese and nickel to a cobalt ground coat gave good adherence over a larger firing range, but the effect of manganese was relatively smaller than that of nickel.

It would seem from Fig. 3 that the gas which produces the reboiling bubble formed at the interface of the enamel and iron and expanded at a rapid rate. This phenomenon was indicated by the oval shape of the small bubble noticed in the upper left part of the enamel.

A study of the photomicrographs, Figs. 5 to 10, inclusive, brings out the following information:

(1) Enamel containing no metals (Fig. 5, left) does not have a hazy layer and the iron interface is even.

(2) Precipitation of accicular crystals in the enamel was encountered in cobalt glasses (Fig. 6), and these crystals were apparently inhibited by the presence of nickel (Fig. 10). In this latter photomicrograph, a few of these needle-like crystals may be seen when 0.24% nickel is present, but practically all disappear in the presence of 0.72% nickel.

(3) The hazy layer in the enamel was not seen when cobalt was used alone (Fig. 6) but appears to be dependent upon the presence of manganese or nickel (Figs. 5, 7, 9, and 10).

(4) The iron interface was more irregular when cobalt was added to the enamel, but there did not appear to be very much connection between this roughened condition and adherence.

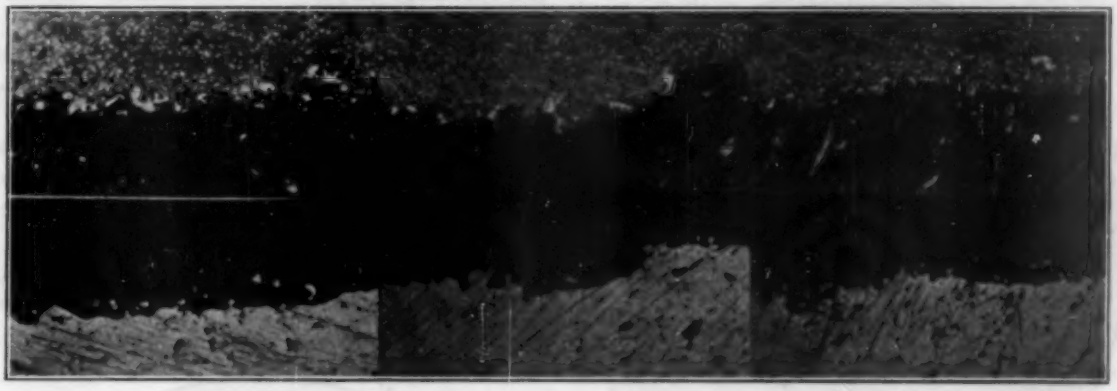

FIG. 9.—*Left*, 1.05% MnO, 0.24% NiO; *middle*, 1.05% MnO, 0.48% NiO; *right*, 1.05% MnO, 0.72% NiO.

FIG. 10.—*Left*, 1.05% MnO, 0.48% CoO, 0.24% NiO; *middle*, 1.05% MnO, 0.48% CoO, 0.48% NiO; *right*, 1.05% MnO, 0.48% CoO, 0.72% NiO.

(5) The small particles in the enamel at the interface, designated by some investigators[2] as dendrites of alpha iron, seemingly were not closely connected with adherence for instances were noted in the case of manganese and nickel where dendrites were as numerous as those seen in cobalt

FIG. 11.—Photomicrograph showing cubical nature of interface of the enamel containing 0.72% CoO. ×1500.

ground coats, although the adherence was considerably less.

(6) There was some evidence in this study that precipitation can take place in the enamel although it was in a molten condition only for a few minutes. In Fig. 11, an indication of precipitation is evidenced by the cubical nature of the dendrites, and some unusual crystals in the enamel appear in Fig. 12.

(7) Because it required the same amount of time for all of the panels to reboil, it was inferred that the metals had no influence upon this property of reboiling.

(8) The metallic oxides apparently do not have much effect upon the thermal expansion and softening temperature of an enamel as indicated by the curves in Fig. 4.

[2] Karl Schwartzwalder and R. M. King, "Mechanics of Enamel Adherence: VI, Petrographic, Metallographic, and X-Ray Study of Enamel-Metal Contact Zones," *Jour. Amer. Ceram. Soc.*, 15 [9] 483–86 (1932).

V. Summary

Cobalt was essential in producing adherence in a ground-coat enamel, while manganese and nickel improved the adherence over a wider firing range with a given cobalt content.

Reboiling was closely connected with adherence, and no matter how the adherence was increased, the reboiling tendency of the enamel was also increased.

Even in the comparatively short time of four minutes, it appeared possible for crystalline material to precipitate out in the enamel.

The hazy layer in the enamel was composed of particles which were microscopical in size but could be resolved at high magnification under dark-field illumination.

There did not seem to be any connection between the presence of ferrous oxide in the enamel layer and the adherence of the enamel to the metal.

None of the metals used with the enamel glass affected the time at which the reboil bubbles would reach their peak of development.

FIG. 12.—Photomicrograph of some unusual crystals in enamel containing 0.72% CoO. ×1500.

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SURFACE TENSION OF VARIOUS MOLTEN GLASSES*

By A. E. Badger, C. W. Parmelee, and A. E. Williams

Abstract

Surface-tension measurements were made on a series of molten glasses at 1200° and 1350°C, using the maximum bubble-pressure method. A base glass was chosen with the composition of 17.4% Na_2O, 10.1% CaO, 72.5% SiO_2, or 1.4 Na_2O:0.9 CaO:6.0 SiO_2, to which 0.030 gram-atom of various elements in the form of their oxides was added.

An increase in surface tension was produced by Li, Si, Ca, Ba, Mn, Ni, Co, Fe, Zn, Al, Mg, Ce, and Zr. A decrease was produced by Ti, Na, B, K, Pb, and V. The values at 1200°C ranged from 235 dynes per centimeter for the glass containing vanadium, to 320 dynes per centimeter for the zirconium-containing glass; the base glass had a value of 304 dynes per centimeter. The surface-tension values at 1350°C were generally slightly less. Surface-tension results for various analyzed commercial glasses are given also for temperatures of 1200° and 1350°C.

I. Introduction

Surface-tension measurements on various glass compositions were obtained with the apparatus of Parmelee and Lyon,[1] which was improved later by Parmelee and Harman.[2] This method of measuring the surface tension of liquids is usually called the maximum bubble-pressure method. The apparatus described in these references is a modification of the method developed by Jaeger[3] to determine the surface tension of fused salts.

II. Chemical Compositions of Glasses

Two series of glasses were used in this investigation. In the first, a series of glasses was prepared for a study of the effect of various oxide additions on the surface tension of a simple soda-lime-silica glass. The second series consisted of commercial glasses, analyzed samples having been obtained from various industrial plants.[4]

In the first series, a glass of the molecular amounts 1.4 Na_2O : 0.9 CaO : 6.0 SiO_2 (which corresponds to 17.4% Na_2O, 10.1% CaO, 72.5% SiO_2) was chosen as a base glass to which additions of various oxides were made on a gram-atomic basis in such a manner that the same numbers of cations were added to the base glass. For example, 0.030 mol CaO was added to the base glass in one sample, while 0.015 mol Na_2O was added to another. These additions contributed equal numbers of calcium or sodium atoms in the respective glasses.

The oxides incorporated in the base glass were as follows, the grouping being arranged according to the Periodic Table:

0.015 mol Li_2O	0.030 mol MgO	0.015 mol B_2O_3	0.030 mol SiO_2	0.015 mol Mn_2O_3	0.015 mol Fe_2O_3	0.030 mol CeO_2
" Na_2O	" CaO	" Al_2O_3	" TiO_2		0.030 mol CoO	" NiO
" K_2O	" ZnO		" ZrO_2			
	" BaO		" PbO			

These additions were made in the form of the above oxides, except that carbonates were used for the alkalis and CaO, and Pb_3O_4 was used as a source of PbO, MnO_2 for Mn_2O_3, Co_3O_4 for CoO, and Ni_2O_3 for NiO.

One other sample was made by adding 0.030 mol CaF_2 to the base glass, and two unclassified samples (Nos. X12 and X19) contained various amounts of B_2O_3 or Mn_2O_3, respectively.

The chemical compositions of these glasses, as computed from the batch, are listed in Table I. The calculations were made on the assumptions that volatilization of cations was negligible, the total iron existed in the trivalent form, Co_3O_4 became CoO, Ni_2O_3 formed NiO, MnO_2 existed as Mn_2O_3, and no CaF_2 was lost. Chemical analyses of the melted glasses may be made later to obtain more exact compositions of the glasses.

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Publication approved by the Engineering Experiment Station, University of Illinois. Part of the expense of this investigation was defrayed by the Graduate School Fund of the University. The authors are pleased to acknowledge the aid of R. J. Krantz and B. C. Viger in the preparation of the glasses.

[1] C. W. Parmelee and K. C. Lyon, "The Maximum Bubble-Pressure (Jaeger) Method for Measurement of Surface Tension of Molten Glass," *Jour. Soc. Glass Tech. (Trans.)*, **21**, 44–52 (1937).

[2] C. W. Parmelee and C. G. Harman, "Effect of Alumina on Surface Tension of Molten Glass," *Jour. Amer. Ceram. Soc.*, **20** [7] 224–30 (1937).

[3] F. M. Jaeger, "Change in Molecular Free Surface Energy of Liquids in the Range from −80° to +1650°C," *Z. anorg. allgem. Chem.*, **101**, 1–214 (1917).

[4] The authors are indebted to various sources for these analyzed glass samples.

The second series, which consisted of glasses of commercial importance, is reported separately in Table III, and the surface-tension values and chemical compositions as determined by analysis are given for each glass.

III. Preparation of Glasses

The first series, consisting of glasses with various additional agents, was made by weighing the chemically pure materials on an analytical balance, mixing them thoroughly, and melting the prepared batch in platinum crucibles in a platinum-resistor electric furnace. The resulting glass was then powdered in a diamond steel mortar, passed over an electromagnet to remove iron, and remelted in platinum. The remelted material was then subjected to the same procedure to produce a homogeneous sample for the tests on surface tension.

TABLE I

CHEMICAL COMPOSITIONS OF GLASSES AS COMPUTED FROM BATCH

(The base glass was 1.4 Na_2O:0.9 CaO:6.0 SiO_2 or 17.4% Na_2O, 10.1% CaO, 72.5% SiO_2, to which additions of various materials were made in accordance with Table I)

Glass No.	Substance added to base glass (mol)		Chemical composition (%)			
			SiO_2	Na_2O	CaO	Additional substance
1	None		72.5	17.4	10.1	0
5	0.015	Li_2CO_3	71.6	17.2	9.9	1.3 Li_2O
6	.015	Na_2CO_3	70.6	16.9	9.8	2.7 Na_2O
7	.015	K_2CO_3	69.6	16.7	9.6	4.1 K_2O
8	.030	MgO	70.0	16.8	9.7	3.5 MgO
9	.030	$CaCO_3$	69.0	16.6	9.6	4.8 CaO
10	.030	$BaCO_3$	63.7	15.3	8.9	12.1 BaO
11	.030	ZnO	67.6	16.2	9.4	6.8 ZnO
12	.015	B_2O_3	70.3	16.9	9.7	3.1 B_2O_3
13	.015	Al_2O_3	69.4	16.6	9.6	4.4 Al_2O_3
14	.030	SiO_2	68.8	16.5	9.6	5.1 SiO_2
15	.010	Pb_3O_4	60.4	14.5	8.4	16.7 PbO
16	.015	Fe_2O_3	67.7	16.2	9.4	6.7 Fe_2O_3
17	.010	Co_3O_4	68.0	16.3	9.4	6.3 CoO
18	.015	Ni_2O_3	68.0	16.3	9.4	6.3 NiO
19	.030	MnO_2	67.7	16.3	9.4	6.6 Mn_2O_3
39	.030	TiO_2	67.7	16.2	9.4	6.7 TiO_2
41	.015	V_2O_5	67.1	16.1	9.3	7.5 V_2O_5
42	.030	ZrO_2	65.3	15.7	9.0	10.0 ZrO_2
43	.030	CeO_2	62.8	15.1	8.7	13.4 CeO_2
44	.030	CaF_2	67.8	16.3	9.4	6.5 CaF_2
X12	.0133	B_2O_3	70.6	16.9	9.8	2.7 B_2O_3
X19	.041	MnO_2	66.0	15.8	9.1	9.1 Mn_2O_3

The glasses in the second series (commercial glass melts) were used without additional preparation.

IV. Results of Tests

To determine the difference in results which might be expected from personal errors, the surface tension of the first series of glasses was determined in duplicate by different observers. If unsatisfactory checks were obtained, a third glass was made and tested. Usually two sets of glasses were sufficient. These were prepared by the standard procedure, and the surface-tension tests were made by two different observers. These duplicate tests, therefore, include all accidental errors associated with the determination of ignition losses of the batch materials, the weighing of the materials, and the melting procedure, as well as the measurement of surface tension itself. The latter measurement was checked several times at each temperature, the precision[2] of the measurement being about 1.5 dynes per centimeter or ± 0.5%. The difference in the surface-tension values obtained on supposedly identical glasses is considerably greater in some cases than the precision of measurement, as may be seen from Table II, which summarizes the surface-tension measurements of the glasses in the first experimental field. The results furnished an estimate of the total error involved in preparing the glasses and in the measurement of surface tension.

Referring to Table II, column (2) gives the additional substance which was present in the base soda-lime-silica glass. Columns (3) and (4) show the surface-tension values of these glasses at temperatures of 1200°C, as obtained by the two observers. A similar comparison of values at 1350°C is afforded in columns (7) and (8).

These surface-tension results represent tests made on supposedly identical glasses as made up from individual batches. The maximum difference between the average value for a glass and a single determination is shown in columns (6) and (10) of Table II, the average of all these differences being 2.5 dynes per centimeter. This latter value corresponds to an error of about ±1%, which indicates the accuracy to be expected when different observers prepare supposedly identical glasses from chemically pure materials. The precision of determining the surface tension of any individual glass is considerably better, ± 0.5% being a conservative estimate.

The average values of surface tension at 1200° and 1350°C are given in Table II, columns (5) and (9), respectively. From these values, a mean temperature coefficient of surface tension over the noted interval may be computed for any glass. This temperature coefficient is usually a small negative fractional number. Exceptions are the glasses containing PbO (No. 15) or V_2O_5 (No. 41),

TABLE II

SUMMARY OF SURFACE-TENSION MEASUREMENTS OF GLASSES AT 1200° AND 1350°C
(Results of two different observers on supposedly identical glasses)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		At 1200°C				At 1350°C			
		Surface tension (dynes/cm.)				Surface tension (dynes/cm.)			
Glass No.	Additional substance present in base glass	First observer	Second observer	Av. value	Max. diff. between av. and single determination	First observer	Second Observer	Av. value	Max. diff. between av. and single determination
1	None	305.9	301.2	304	2.4	304.1	300.3	302	1.9
5	Li_2O	309.7	305.7 303.8	306	3.3	308.9	304.3 302.2	305	3.8
6	Na_2O	302.5	298.0	300	2.3	300.0	295.6	298	2.2
7	K_2O	291.0	292.1	292	0.6	287.6	284.5	286	1.6
8	MgO	316.5	315.3	316	0.6	314.9	313.1	314	0.9
9	CaO	313.5	311.1	312	1.2	311.7	308.4	310	1.7
10	BaO	309.8 314.8	312.4	312	2.5	308.7 313.5	309.7	311	2.9
11	ZnO	317.6	311.1 315.3	315	3.6	315.8	309.1 309.6	312	4.3
12	B_2O_3		293.7	294			289.7	290	
13	Al_2O_3	316.7	314.1	315	1.3	315.4	310.8	313	2.3
14	SiO_2	311.0	305.4 304.0	307	4.2	309.4	301.2 298.4	303	6.4
15	PbO	273.1	272.4	273	0.4	277.3	274.0	276	1.7
16	Fe_2O_3	321.2	310.5 311.1	314	6.9	317.3	307.6 307.7	311	6.4
17	CoO	310.6 320.5	310.2	314	6.7	314.1 317.7	308.4	313	5.0
18	NiO	314.5	311.2	313	1.7	312.7	308.7	311	2.0
19	Mn_2O_3		310.8 314.1	312	1.7		308.9 310.6	310	0.9
39	TiO_2	301.0	300.7	301	0.2	298.5	300.6	300	1.1
41	V_2O_5	235.7	233.2	235	1.3	237.5	234.2	236	1.7
42	ZrO_2	318.5	321.8	320	1.7	315.8	311.5	314	2.2
43	CeO_2	321.6	316.8 314.6	318	3.9	317.6	313.1 314.0	315	2.7
44	CaF_2	307.7	309.1	308	0.7	302.5	305.6	304	1.6
X12	B_2O_3	298.4				294.7			
X19	Mn_2O_3	320.0				319.4			

where the surface tension increases at the higher temperature. In the case of the lead glass, the surface-tension reading at 1350°C may have been vitiated by the slight volatilization of PbO. The positive temperature coefficient shown by V_2O_5 is within the experimental error.

The agreement of the results of the two observers would be expected to be quite poor in the measurement of glasses containing materials like Fe_2O_3, which dissociate with rise in temperature and require time to reach the equilibrium state.

The average surface-tension values of the glasses at 1200°C, which are given in Table II, column (5), are illustrated in Fig. 1. A similar graph of the values at 1350°C would show slightly lower values with the exception of the glasses containing PbO or V_2O_5.

The results of the surface-tension measurements of various commercial glass samples, whose chemical compositions had been determined by analysis, are given near the bottom of Table III in connection with the individual glasses. The precision of these results is about ±0.5%.

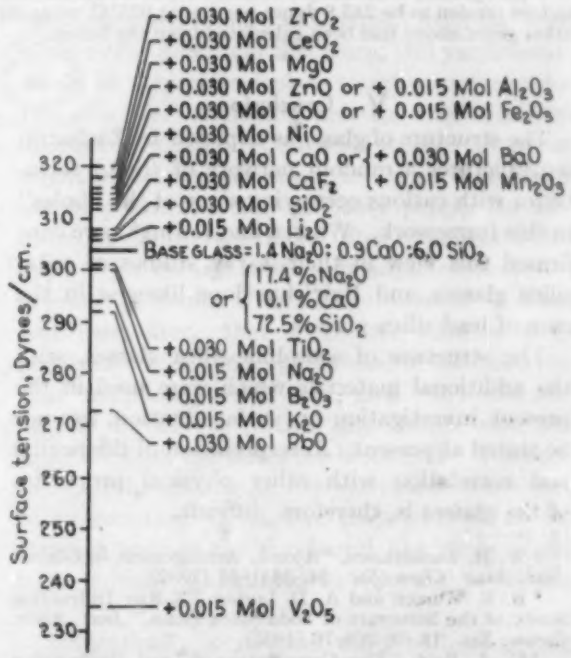

FIG. 1.—Effect of additions on surface tension of base glass at 1200°C.

TABLE III

SURFACE TENSION AND CHEMICAL COMPOSITIONS OF SOME COMMERCIAL GLASSES

	Designation of Glass							
	A*	B†	C**	D	E	F	G	H‡
SiO_2	74.1	65.35		72.56	74.52	70.74	72.50	40.9
B_2O_3			0.70	1.00				17.5
PbO		17.50						
Fe_2O_3	0.065	0.049					0.09	trace
Al_2O_3	0.33	0.18					1.06	7.7
R_2O_3				3.58	0.45	0.33		
CaO	4.65	0.21		4.02	4.35	13.72	9.24	8.4
MgO	3.23	0.03		2.54	3.18	0.12	3.00	
P_2O_5		0.23						
K_2O	0.04	8.40						4.5
Na_2O	16.65	5.70				13.11	13.59	15.3
Alkalis				16.30	16.51			
SO_3	0.41	0.03						
Na_2SO_4						0.85	0.41	
As_2O_3	0.03	0.03				0.25		
As_2O_5	0.07	0.36						
NaCl						0.86	0.11	
Cl	0.047	0.05						
BaO		1.40			0.99			
TiO_2	0.02	0.01						
ZrO_2	0.003	0.005						
MnO	0.003	0.088						
MnO_2								1.2
NiO								0.5
CoO								0.6
F_2								3.5
Ignition loss	0.30	0.32						
Total (%)	99.948	99.942		100	100	99.98	100	100.1
Surface tension at 1200°C (dynes/cm.)	303	247	307	302	304	313	318	
Surface tension at 1350°C (dynes/cm.)	302	245	299	299	300	314	315	
Surface tension at 925°C (dynes/cm.)								244

* National Bureau of Standards glass No. 80.
† National Bureau of Standards glass No. 89.
** National Bureau of Standards glass No. 92. Analysis to be available at later date.
‡ Soft ground-coat enamel obtained from W. N. Harrison, National Bureau of Standards, who had determined the surface tension to be 245.8 dynes per cm. at 925°C, using an improved dipping cylinder method. The chemical composition given above had been calculated from the batch.

V. Conclusions

The structure of glass, as depicted by Zachariasen,[5] pictures a random network of (SiO_4) tetrahedra with cations occupying some of the "holes" in this framework. Warren and Loring[6] have confirmed this view in their X-ray studies of soda-silica glasses, and Bair[7] has done likewise in the case of lead-silica glasses.

The structure of soda-lime-silica glasses, with the additional materials which were used in the present investigation on surface tension, can not be stated at present. Interpretation of the results and correlation with other physical properties of the glasses is, therefore, difficult.

Some brief statement is possible regarding the surface-tension measurements of the glasses containing additions of alkalis. These values were in the order Li>Na>K. The same order was found in Jaeger's determinations of the surface tensions of molten salts of these metals.[3] Among these metals, there are many other properties in which sodium has an intermediate position, such as the melting points of the elements, heats of formation of their oxides, ionic radii, etc. Such an intermediate position is to be expected from the order of the alkalis in the periodic table.

The effects of other oxide additions can not be classified readily according to the periodic grouping (see Fig. 1). Many of the additions, however, produced similar effects on surface tension, and a certain grouping is possible, as follows: (1) atoms of Zr and Ce increased the surface tension about 5%; (2) an increase of about 3% was produced by the atoms of Mg, Zn, Al, Co, Fe, Ni, Ca, Ba,

[5] W. H. Zachariasen, "Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54**, 3841–51 (1932).
[6] B. E. Warren and A. D. Loring, "X-Ray Diffraction Study of the Structure of Soda-Silica Glass," *Jour. Amer. Ceram. Soc.*, **18** [9] 269–76 (1935).
[7] G. J. Bair, "The Constitution of Lead Oxide-Silica Glasses: I, Atomic Arrangement," *ibid.*, **19** [12] 339–47 (1936).

Mn; (3) an increase of about 1% was caused by Si and Li; (4) Ti and Na decreased the surface tension about 1%; (5) a decrease of 2% was produced by atoms of B and K; and (6) atoms of Pb decreased the surface tension about 10%, while V caused the greatest lowering among the group, about 23%.

This grouping is only approximate and refers to the effect on the surface tension at 1200°C of the glass 1.4 Na_2O:0.9 CaO:6.0 SiO_2 (or 17.4% Na_2O, 10.1% CaO, 72.5% SiO_2) when additions of 0.030 gram-atom of the elements are incorporated as oxides in the base glass.

Some additional tests were made on the surface tension of glasses prepared from batches in which part of the Na_2CO_3 was replaced by equivalent amounts of Na_2SO_4 or $NaNO_3$. No change in surface tension could be observed as the result of such substitutions.

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CONCERNING THE STRENGTH OF THE WEAKEST BOTTLES*

Applicability of the "Normal" Curve of Errors to Statistical Analyses of Strength Tests of Glassware

By F. W. Preston

Abstract

The ordinary "theory of errors," which assumes a "normal distribution" of the errors, is often applied to situations where it can not theoretically apply. In particular it has been applied to the strength of glass and glassware. While theoretically the theory is wrong, there is no entirely satisfactory theory available to replace it, and the question arises how far it can be used with advantage and exactly what are its limitations. It is necessary to answer these questions by direct experiment, *i.e.*, by breaking a lot of glassware.

I. History

Hampton has made a number of comments on the variability of the strength of glassware[1] and on the standard deviation[2] he has usually found in experimenting. Dudding and Baker[3] discuss the theory somewhat elaborately, giving experimental data on thermal-shock tests of glass rods, and there are several other papers dealing with strength, in which reference is made to "probable errors" or "standard deviations." It does not seem necessary to review the literature, either in English or foreign languages, in any detail, since as far as the writer is aware none of it deals with, or even mentions, the point to be considered here, *viz.*, the impossibility of the theory being theoretically correct.

II. Background of the Theory

Across the creek from my office window the land rises in a steep wooded escarpment from the flood plain to the hills. On this scarp, 200 yards away, would be an excellent place to set up a target for rifle practice. Assuming that the rifle is a good one, the light fair, and the wind steady, the writer might proceed to shoot at the target and (being out of practice) would probably pepper the surrounding countryside more often than the bull's eye. With the sights properly adjusted, however, it would be found, after a large number of shots had been fired, that a greater number were gathered within the neighborhood of the bull's eye than within any other *equal* area. It would also be found that the further any chosen area was from the bull, the fewer the shots in it. Furthermore, in the absence of any systematic error, due to an unnoticed increase of cross-wind or an increasing warp of the gun-barrel, the shots ought to be equally distributed to right and left of the bull.

Theoretically, occasional shots will go a long way to left or right, and they can go *equally far* to left or right. Theoretically, in fact, if I shoot

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* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Glass Division).

[1] W. M. Hampton and C. E. Gould, "Some Implications of Known Variation in Strength of Glass," *Jour. Soc. Glass Tech.*, **18** [71] 194–200 (1934); *Ceram. Abs.*, **14** [4] 90 (1935).

[2] *Loc. cit.*, page 195.

[3] B. P. Dudding and I. M. Baker, "Application of Statistical Methods to Quality Control of Manufactured Products," *Jour. Soc. Glass Tech.*, **17** [67] 239–59 (1933); *Ceram. Abs.*, **13** [3] 59 (1934).

long enough, one or two shots may be found directly behind me instead of in front. The deviation could, theoretically, still be equally to left or right, and the chances are equal of either side being favored.

The statement made "with the sights properly adjusted" means, when reduced to mathematical terms, that when every bullet has found its billet, in the target or the surrounding shaly cliff, the center of gravity of all the spent bullets will lie in the bull's eye (or at least on the line joining my eye to the bull's). The center of the bull's eye is the "mean" or "average" position of the bullets.

Let distances measured to right or left of the bull be called x (plus to the right, minus to the left, as usual). Let the number of bullets in a distance δx inches be n, where n is a function of x. Then the foregoing statement that there will be equal numbers of bullets in the element, δx, whether x is plus or minus, means mathematically that $F(x)$ is of the form $F(x^2)$, no odd powers of x occurring.

Leaving out all intermediate stages of the argument, mathematicians have concluded that the distribution of bullets should be governed by a law of the form

$$n = n_0 e^{-kx^2} \qquad (1)$$

Where n = number of bullets occurring in the interval δx between x and $x + \delta x$.
n_0 = number occurring in the interval next the bull's eye from $x = 0$ to $x = \delta x$.
k = a constant depending on accuracy of shooting.

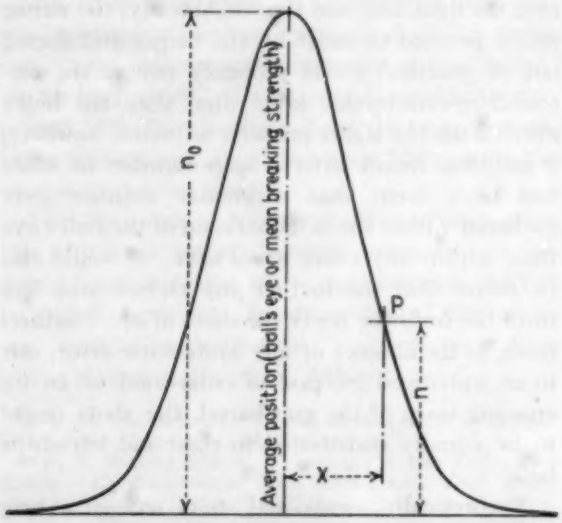

FIG. 1.—Normal curve of errors $n = n_0 e^{-kx^2}$, showing its symmetrical character.

The values of n and n_0 clearly depend on the total amount of ammunition I have expended. If I shoot twice as many bullets all told, n and n_0 will also both be doubled. A similar equation applies to the vertical components (y) of the errors.

The curve plotted from equation (1) is of the general form of Fig. 1. It extends to an infinite distance left and right, and there is no obvious reason why it should not.

III. Theoretical Impossibility of This Curve Fitting Strength of Glassware Tests

Let us break a large number of bottles by internal (hydrostatic) pressure and measure the breaking pressure in each case. Let the average value be 400 pounds per square inch. Bottles, like all glassware, are variable, and we are apt to find a few bottles with a strength of 800 pounds per square inch or higher; theoretically the sky is the limit. But it is inconceivable that any bottle should have less than zero strength. Thus the curve can not possibly extend to infinity in both directions. It must come to a complete and abrupt end on the low strength side. Expressed briefly, there is theoretical reason to expect that the curve of distribution will not be symmetrical, or in technical language that it will be "skew," and that it will not be of the e^{-ax^2} form, which is a symmetrical curve.

There is nothing out of the ordinary in a statistical curve being skew, and there is the same theoretical reason to expect skewness in many curves which, apparently, do not show skewness to an extent that is bothersome. For instance, the weight of a glass technologist can not go below zero, but occasional specimens might theoretically be found whose weight is more than twice the average.

Again, the individual molecules of a gas can not have a kinetic energy less than zero, but occasional molecules may have energies many times the average. This is so obvious that the theory does not begin with the assumption that the curve is of the form

$$n = Ae^{-kx^2}$$

Where x = kinetic energy.

But with the form (derived theoretically

$$n = A\sqrt{x}\,e^{-kx^2}$$

which becomes imaginary if x is negative; in other words, the curve comes to an end at $x = 0$ (zero kinetic energy).

We are not, therefore, calling attention to a new phenomenon or to some point never envisaged before in the theory of statistics; we are simply raising the question whether glass bottles or other articles of glassware really conform sufficiently well to the "normal curve of errors" to warrant our using that curve for purposes of calculation.

Flint and Lyle[4] do not deal with skewness; they do, however, carefully point out that their figures and tabulations are warranted only *if* the curve is normal. The question whether in practice the curve *is* normal is one they do not discuss. (Their attitude may be fairly illustrated by a quotation from page 364 of the article cited.)

"This figure" (the standard deviation) "is significant, in that it indicates the range within which two-thirds of the values will be found, providing the values have a normal distribution. Further, we know that only one value in 3 can exceed it, one value in 22 can be twice as great as σ, one value in 370 can be three times as great as σ, one value in one thousand million can be six times as great as σ.

This helps to indicate the frequency with which variations greater than σ may be expected in a test. It is of real value in indicating the trustworthiness of the test . . . ."

Gould and Hampton[5] publish a figure showing the distribution curve for thermal endurance of certain glassware, and the curve lies reasonably well among the observed points.

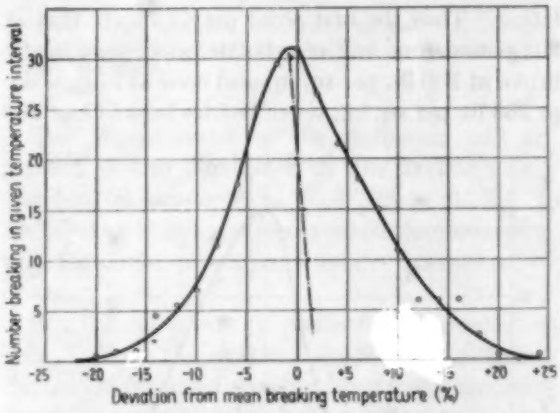

FIG. 2.—Thermal shock tests of about 250 beakers (Gould and Hampton's data, replotted). The skew or asymmetrical curve fits the results better than a symmetrical curve.

"Dr. Hampton, on a visit to this laboratory while the present paper was being written, says that an ordinary 'normal' curve does, in fact, fit the results quite well. About 250 individual specimens were involved."

A number of years ago the present writer, with U. E. Bowes, made an investigation of 1000 bottles broken by thermal shock, and the curve seemed quite symmetrical. Not enough points on the curve were determined, however, to make the test conclusive, *i.e.*, the increments in thermal differential were too great.

Thermal shock is not a matter solely of temperature difference, for "dry-ice" at 100° below zero (Fahrenheit) will not break a bottle filled with boiling water, while water at 40°F often will (the chilling in each case being applied to the outside while the bottle is hot). It was decided, therefore, to use pressure tests rather than thermal shock and to break 1000 bottles by hydrostatic internal pressure at room temperature.

The first tests were made under the direct supervision of R. G. Hunter, and the bottles were the whole "pack" taken in a straight run from the leer of a single Owens AQ machine operating normally; the inspecting at the leer end was normal commercial operation, and the bottles were tested to destruction by a steadily rising pressure. Dr. Hunter estimates that the pressure rose at about 700 pounds per square inch per second. The breaking pressure was estimated to 10 lb. per sq. in., sometimes to 5 lb. per sq. in. It was found, however, that, presumably through a subconscious tendency on the part of the operator to prefer "round" figures, there were more bottles recorded as breaking at 400, 450, and 500 than at 390, 410, and 440, or the "odd" figures, and it became necessary to add the results in pairs; thus (300 and 310) were treated as 305 and similarly (440 and 450) which were plotted as 445. The tabulation follows:

TABLE I

Pressure	No. breaking	Pressure	No. breaking	Pressure	No. breaking
305	10	505	88	705	4
325	21	525	67	725	6
345	30	545	42	745	2
365	51	565	28	765	0
385	65	585	10	785	0
405	106	605	15	805	1
425	112	625	11	825	1
445	118	645	3	845	0
465	112	665	5	865	0
485	88	685	1	885	1
				905	2

[4] F. C. Flint and A. K. Lyle, "Statistical Methods for Routine Testing of Bottles," *Jour. Soc. Glass Tech.*, **16** [63] 360–74 (1932); *Ceram. Abs.*, **12** [2] 53 (1933).

[5] C. E. Gould and W. M. Hampton, "Thermal Endurance of Glass," *Jour. Soc. Glass Tech.*, **14** [54] 188–204 (1930); curve p. 192; *Ceram. Abs.*, **9** [10] 830 (1930).

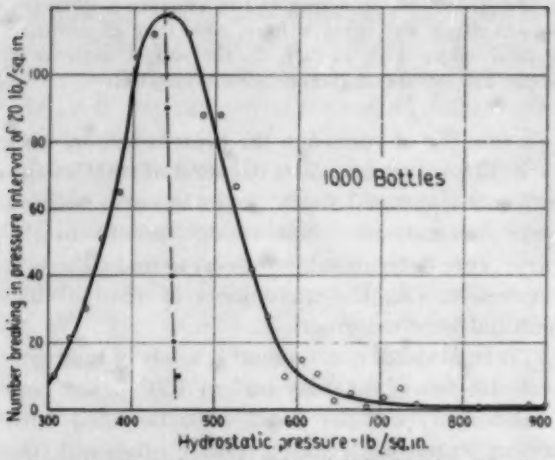

FIG. 3.—Breaking strengths of 1000 bottles, showing asymmetrical or "skew" character. The skew axis, departing distinctly from the vertical, is shown. The dots are points plotted half way between ascending and descending legs of the curve (Hunter's data).

The results are graphed in Fig. 3. Only a skew curve will fit these results. The amount of skewness may be estimated from the nearly vertical, slightly sloping line drawn through the dots. The dots are points plotted midway between the limbs of the smoothed curve.

Calculations made on the lines suggested by Flint and Lyle in the quotation given will therefore be inapplicable. Such calculations would indicate that out of 1000 bottles, about 20 should have a strength of less than 300 lb. per sq. in., and, as a matter of fact, we find none. On the other hand, we get about 40, instead of the expected 20, with strengths beyond 600 lb. per sq. in.

There is some evidence, however, that the curve is bimodal and that the bottles consist of two kinds, one of which is much stronger than the other but is present in relatively small numbers. The two kinds can not be distinguished by any examination or test other than a test to destruction for they are nominally all identical.

Believing that we knew the cause of this bimodal distribution, we made preparations for another test of another 1000 bottles, made several months later but on the same machine and having the same general appearance.

NOTE: Dr. Hunter, in view of the great amount of work involved in the testing and in its analysis, considered that we should improve the testing equipment to eliminate as far as possible the human element in the processes of testing. Accordingly, we designed and constructed an automatic testing machine, using pressures rising rapidly but under control of an electric motor, and we shipped it to the plant where the testing was to be done. The machine is not described in detail here because a better version has since been constructed with which later work was done.

The number of bottles, out of 1000, that broke at a particular gage reading were as follows:

TABLE II

(1) (lb./in.²)	(2)	(1) (lb./in.²)	(2)	(1) (lb./in.²)	(2)
230	1	310	40	410	60
240	0	320	56	420	27
250	1	330	70	430	37
260	2	340	99	440	11
270	12	350	106	450	17
280	5	360	101	460	2
290	13	370	74	470	1
300	25	380	95	480	2
		390	80	490	0
		400	62	500	1

Total 1000 bottles

(1) = gage reading.
(2) = number breaking.

The average, or mean, strength was 364 lb./sq. in.; 469 bottles were above the mean and 531 below it.

$$\sqrt{\frac{\Sigma\delta^2}{1000}} = 39.2 \text{ lb./sq. in.} \quad 0.67\sqrt{\frac{\Sigma\delta^2}{(1000)(999)}} = 1.24$$

The results are plotted in their raw state (Fig. 4), using the data given in Table II. Then, in view of the tendency of the operator, however punctilious, to favor certain even terms in place of certain other terms when the reading is in doubt by some 5 lb. per sq. in., another graph (Fig. 5) was made in which each plotted point is the average of two consecutive groups in the above tabulation. Thus the first point may indicate that at 235 pounds one-half of a bottle broke (one bottle broke at 230 lb. per sq. in. and none at 240), while at 265 lb. per sq. in., seven bottles broke (2 at 260

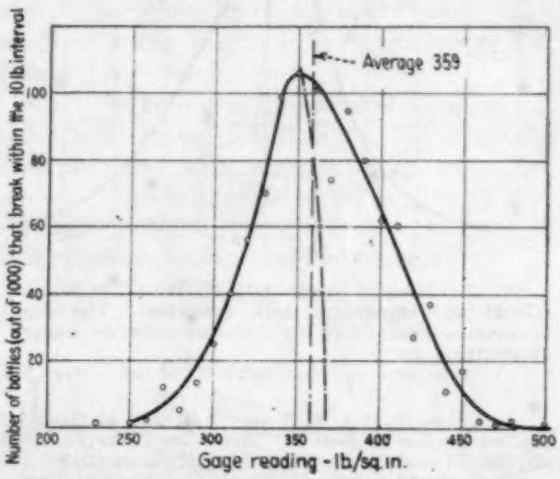

FIG. 4.—Curve of frequency on second investigation, when bottles were tested by improved machine and handled more uniformly throughout.

and 12 at 270). Obviously there are two ways of obtaining pairs in this fashion, according as we start with 220 pounds per square inch (at which none broke) and add this to the 230-pound figure, or begin at 230; *i.e.*, the grouping can be (220 + 230), (240 + 250), (260 + 270), or (230 + 240), (250 + 260), etc.

We have done it both ways in Fig. 5, and it will be apparent that in Figs. 4 or 5 there seems to be some skewness. The long tail to the graph on the high-pressure end, however, has disappeared (Fig. 2). This probably implies that the bimodal distribution has disappeared, the abnormally strong bottles having been eliminated as intended.

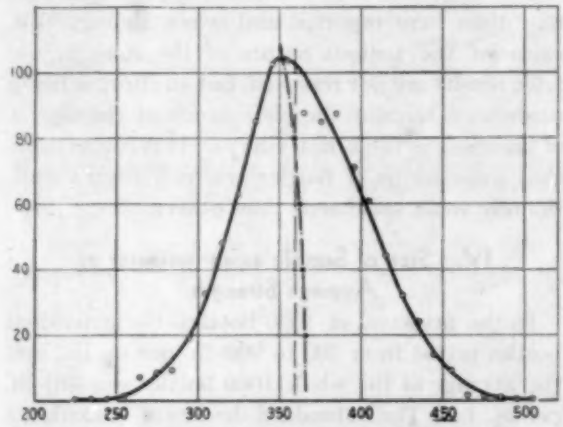

FIG. 5.—Same as Fig. 4, but results are plotted by "pairing" to reduce psychological errors. In Figs. 4 and 5, the smooth curve drawn naturally among the plotted points appears bent over on the top, its axis being the curved broken line, and the modal point lying below the mean.

The improvement in the technique and apparatus is also illustrated by the decline in the standard deviation from 50.4/379 = 13.3% to 39.2/364 or 10.8%, as calculated on the assumption that the curves are approximately "normal curves of errors."

But this, of course, is precisely the question at issue. From the graphs, one would think that the curves departed sensibly from that shape, and yet their general form is not so very different. It becomes necessary to use more refined statistical methods.

For this purpose we have recourse to the methods outlined by Elderton,[6] who states that frequency curves are of three main types and ten transition types. The "normal curve" is one of the transition types.

The calculations to decide which type is involved in a particular case are tedious in the extreme, but it may be said that their purpose is the determination of 3 discriminants, called by Elderton β_1, β_2, and κ.

Operating on the data in Table II, the writer obtained the values

$$\beta_1 = +0.00277 \quad \beta_2 = +2.94 \quad \kappa = -1.59 \times 10^{-1}.$$

As the chances of error in the calculations are numerous, W. M. Hampton made a similar calculation on the same figures and obtained

$$\beta_1 = +0.0028 \qquad \beta_2 = +2.972,$$

which agrees sufficiently well with my own results.

In order that the curve should be a normal curve of errors, or normal frequency distribution, the values should be

$$\beta_1 = 0, \qquad \beta_2 = 3, \qquad \kappa = 0,$$

and the values actually obtained are so close to this that Dr. Hampton doubts if they have any real significance.

If they do have a real significance, they indicate that the curve is of Elderton's type I, because κ, though very small, is negative. Type I is one of the main types, while the "normal curve" is a transition type.

Examination of various other sets of data always discloses a departure from the theoretical figures for a normal curve of errors, but the departure is never very great and seems to become less with improvements in methods of testing. The actual departure appears to vary somewhat with different types of bottles, and the subject is apparently complicated. Theoretically the curve should be skew, and in practice we find it to be slightly so.

It appears that the ordinary theory (that which is, strictly, applicable only to the normal or Gaussian curve) may very properly be used to calculate standard deviations, as giving an idea of the consistency of the results.

But it is not proper to attach any significance to the assumed remote parts of the curve, as was done (though with a warning) by Flint and Lyle[4] or by Hampton and Gould,[1] who made the following statement:

"Considering, for instance, the set of beakers, the breaking temperatures of which are given in Table I of the previous paper by the authors, Figure 2 of that paper shows

[6] W. P. Elderton, Frequency Curves and Correlation. 2d ed., 1927. Charles & Edwin Layton, London.

the 'normal' distribution curve, together with the experimental points." (See p. 195, footnote reference 1.) "From the figures given, it may be shown that the coefficient of variation is, in this particular case, 7.2%, and the general shape of the curve is sufficiently in agreement with the points to indicate that the variations are of the type generally known as 'random.' Assuming, therefore, from this, and much other unpublished evidence, that any property of glass which involves tensile strength will show variations in accordance with the 'normal' law and a coefficient of variation of the order of 10%, one can immediately compute the probability of the occurrence of variations of different extents and the property considered. Tables of the proportions of the articles having specified values of the property which are likely to lie outside certain limits have been published, and the following table gives some indication of the nature of the figures."

Probability that a measurement will occur once in	Distance of measurement from mean value, corresponding to probability in previous column
100,000	4.417 × standard deviation
10,000	3.890 " "
1,000	3.290 " "
100	2.576 " "
10	1.645 " "

(Table I from Hampton and Gould reference, p. 196, footnote 1.)

A curve of frequencies is not necessarily a law of nature; it is a man-made procedure known as "graduation." It is a device for replacing the actual groupings of nature by a smooth curve which is more convenient for our calculations. The results are under no obligation to conform to our curves, and the assumption that we can extrapolate to vast distances is not warranted.

The assumption that a small but finite number of bottles will have negative strength is patently absurd, and the evidence is that there ought to be no bottles of zero strength or even approximately zero strength. On the other hand, unless special precautions are taken, a few bottles will have abnormally high strengths, and there seems a likelihood that, in general, bottles are

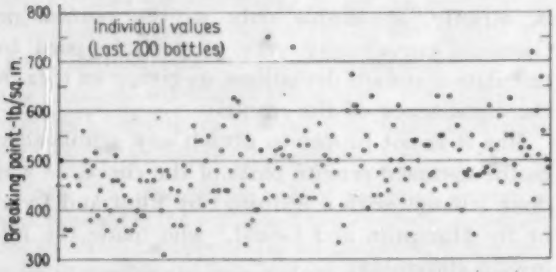

FIG. 6.—Breaking strengths of a sequence of 200 individual bottles (Hunter's data). This is given to show the wild fluctuations of individual bottles. (The horizontal scale is the chronological or ordinal number of the bottle.)

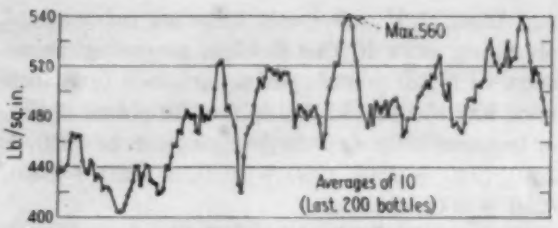

FIG. 7.—Averages-of-ten, for the last 200 bottles out of the thousand, showing that this average fluctuates over very wide ranges even in a couple of minutes' production.

better than the "normal" theory would indicate. They are better more particularly in the absence of very weak specimens.

The work has been continued a good deal further than here reported and is continuing. Because of the tedious nature of the subject, the later results are not reported, but an effort is being made to determine the consistency of the degree of skewness in the actual curves. It is conceivable that some forms of bottles are freer from exceptionally weak specimens than others.

IV. Size of Sample as an Indicator of Average Strength

In the first test of 1000 bottles, the individual bottles tested from 300 to 900 lb. per sq. in., and the average of the whole 1000 bottles was 461 lb. per sq. in. The "standard deviation" calculated for the whole 1000 bottles was 74 lb. per sq. in.

Figure 6 shows a plot of a few hundred of the consecutive observations on the individual bottles, and it will be obvious that the scatter or spread is quite large and the general drift of the results very difficult to interpret. When the whole 1000 is considered, there is some suspicion that toward the end the average is higher than at the beginning, and low values of individual tests are getting scarce.

To reduce the observations to a more readily grasped form, by reducing the scatter, one thousand figures representing averages-of-ten were calculated. The first of these figures is the average strength of bottles 1 to 10, the second is the average of numbers 2 to 11, the third of numbers 3 to 12, and so on. The nine hundred and ninety-first is the average of numbers 991 to 1000, and is the last one of interest. The other nine treat numbers 1 to 10 as if they were 1001 to 1010, and provide a check on the working.

Figure 7 shows about a couple of hundred of these figures plotted; as a matter of fact, the last

200 or so out of the 1000. It is clear that there is still a good deal of scatter and also that, for some reason, the product is increasing in strength.

Of these 991 figures, the lowest average-of-ten is 385 lb. per sq. in., and the highest 560 lb. per sq. in. The average is necessarily the same as before, *viz.*, 461 lb. per sq. in. The averages-of-ten change quite rapidly, and within a space of ten or eleven bottles the average can rise or fall nearly 100 lb. per sq. in.

The standard deviation calculated from a group of ten varies greatly according to which ten is picked. At the point *G* (the maximum average whose average is low, the probable error of the average will also be low.

V. Averages of Fifty

Since ten bottles may appear too few to tell us all we should like to know about the true properties of the whole 1000 bottles, 950 averages-of-fifty consecutive bottles were taken. The first figure is the average of bottles 1 to 50, the second the average of numbers 2 to 51, and so on.

The maximum figure for the average-of-fifty is 514; the minimum is 421. The average is necessarily still near 460.

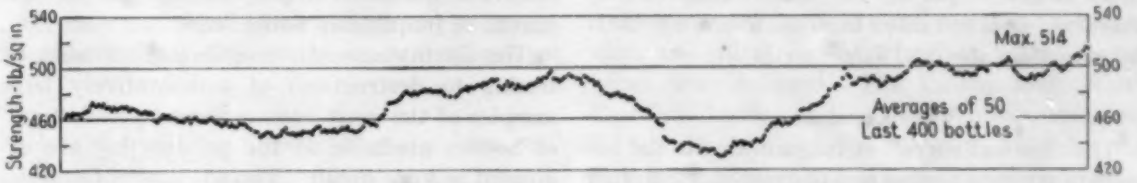

FIG. 8.—Averages-of-fifty, for the last 400 bottles out of the thousand, showing that even with 50 we can not be sure of striking a figure that is at all typical of the average of 1000.

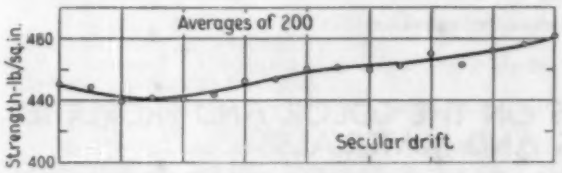

FIG. 9.—Averages-of-200, for the whole 1000 bottles, showing that even an average of 200 is not a constant figure and that there seems to be a secular drift, or change of quality, over a period of a few minutes.

560 lb. per sq. in.), the standard deviation is 70 lb. per sq. in., as calculated from the ten individual values whose average gives the value, *G*. At the minimum point, 385 lb. per sq. in., the standard deviation is 47 lb. per sq. in. At a point on one of the steep slopes, where the average is changing rapidly, a standard deviation of 102 lb. per sq. in. was found, and this may not be the greatest value of the standard deviation.

It may be pointed out that extreme values of the average will tend to be associated with strictly moderate or even minimum values of the standard deviation, while average values of the average-of-ten will tend to be associated frequently (but by no means invariably) with high values of the deviation. This fact is of practical importance only in one respect, *viz.*, that if ten bottles are taken and tested, and we happen to get ten

A plot of the whole of the 950 figures shows that usually the average of 50 would give a very fair idea of the average of 1000, but there were fluctuations in the quality of the product or in the testing procedure; it takes only a little more than 10 minutes to make 1000 bottles, and the greatest fluctuations take place within a space of a couple of minutes. This point is interesting. The possibility that there may have been some undetected variation in the treatment the bottles got on inspecting or testing must also be kept in mind (see Fig. 8).

The curve of the average of 50 is still rising at the finish, and the indications are that if another 100 bottles had been tested, they would have been higher yet.[7] Thus the average of 1000 bottles may depart from the average of a four-hour shift by an appreciable amount.

VI. The Secular Drift

The general drift of the results from beginning to end of the 1000 is upward; this is clear from the averages-of-50. To damp out the small-scale fluctuations still further, averages-of-200 were calculated. This was not done on such an ambitious plan as the average of 10 or 50, but some 20 points on the curve were calculated and plotted. The

[7] The maximum point (514 lb./sq. in.) is the 949th figure, out of 950.

results are given in Fig. 9. A smooth curve drawn between the points thus obtained shows the improvement in the latter part of the run. Whether this improvement is due to some unknown improvement in the quality of the glass from the tank or the operation of the Owens machine or whether it is due to a slight shift in the annealing schedule, to gentler handling by the inspector, or to some unnoticed acceleration of the rate of loading in the testing machine can not now be determined.

The maximum average of 200 (out of the 20 calculated points) is 481 lb. per sq. in.; the minimum is 439 lb. per sq. in. The average of 200, therefore, does not differ from the average of 1000 by more than about 20 lb. per sq. in.

VII. Conclusion

The "normal curve" of frequencies fits the results of pressure testing and thermal-shock testing of glassware sufficiently well that investigators may properly calculate their averages, probable errors, and standard deviations as if the curve were rigorously applicable, thus facilitating comparison of their own results with those of other investigators.

On the other hand, the curve in practice does not fit with so much precision that it can be extrapolated at all beyond the observed limits, and estimates of how weak or how strong the weakest or strongest bottle out of 100,000 or one million will be are quite beside the point. Neither theory nor experiment justifies any such extrapolation.

The slight skewness of the curves obtained experimentally is in the direction to be expected theoretically.

Bottles (and presumably other glass articles) are somewhat better in practice than the "normal curve" of frequencies would imply.

The fluctuations of strength (as indicated by testing to destruction) of comparatively large samples of the most homogeneous "populations" of bottles available at the present day are examined in some detail. The adequacy of samples of various sizes is discussed, and the fact that one thousand bottles are only a sample, not necessarily typical of 10,000, is indicated by the secular drift.

BUTLER, PENNSYLVANIA

EFFECT OF IRON AND ITS COMPOUNDS ON THE COLOR AND PROPERTIES OF CERAMIC ENGOBES AND MATERIALS*

BY T. N. MCVAY AND C. W. PARMELEE

ABSTRACT

Iron compounds were introduced into engobes of varying clay, silica, and feldspar content by (1) direct additions of commercial iron oxide, (2) adsorption from ferric hydroxide sols, (3) use of stains composed of calcined mixtures of ferric and aluminum hydroxides, (4) addition of silica gel in which ferric hydroxide was precipitated, and (5) precipitation with ammonia as the hydroxide from ferric chloride. Methods (4) and (5) were the most satisfactory. Buff colors were obtained with engobes of high clay, browns with high silica, and reds with high feldspar contents. A general study was made of the coloring of ceramic materials by iron oxide, and it was found that the particle size of these materials as well as that of the ferric oxide was of primary importance. An investigation of the effect of gases on the iron oxide present in engobes gave results that are in agreement with the work done on the oxides of iron at the Geophysical Laboratory of the Carnegie Institution of Washington.

I. Introduction

Posnjak and Merwin,[1] Kurnakow and Rode,[2] Thiessen and Köppen,[3] Böhm,[4] Foote,[5] Foote, Scholes, and Langley,[6] Weiser,[7] and Ayres and

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* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (White Wares Division).

[1] E. Posnjak and H. E. Merwin, "Hydrated Ferric Oxides," *Amer. Jour. Sci.*, [4] **47**, 311–48 (1919).

[2] N. S. Kurnakow and E. Y., Rode, "Chemical Constitution of Natural Hydrated Iron Oxide," *Z. anorg. allgem. Chem.*, **169** [1–3] 57–80 (1928).

[3] P. A. Thiessen and R. Köppen, "Hydrated Iron Oxide with a Definite Composition," *ibid.*, **189** [1] 113–36 (1930); *Ceram. Abs.*, **10** [5] 379 (1931).

[4] I. J. Böhm, "Aluminum and Iron Hydroxide," *Z. anorg. allgem. Chem.*, **149** [1–3] 203–16 (1925).

[5] H. W. Foote, "Nature of Precipitated Colloids," *Jour. Amer. Chem. Soc.*, **30** [9] 1388–94 (1908).

[6] H. W. Foote, S. R. Scholes, and R. W. Langley

Sorum[8] made studies of the hydroxides of iron. Carli,[9] Rohland,[10] and MacCarthy[11] investigated the adsorption characteristics of ferric hydroxide sols. Wilson[12] has summarized the work of Seger[13] on the coloration of fired clays by iron compounds. Orton[14] collected the existing knowledge of his time on the coloration of clays by iron, while Scott,[15] Keane,[16] Yoe,[17] Berdel,[18] and Kinnison[19] did a considerable amount of research on this subject. Radcliffe[20] precipitated ferric hydroxide in a porcelain body. Kuechler[21] studied the lowering of the fusion points of relatively pure clays by iron oxide. Shelton[22] studied the crystals and glasses present in low-grade clays after they had been heated at high temperatures. Walden,[23] Sosman and Hostetter,[24] Ralston,[25] Hostetter and Sosman,[26] Hostetter and Roberts,[27] Greig, Posnjak, Merwin, and Sosman,[28] and Ruer and Nakamoto[29] investigated the dissociation of ferric oxide under various conditions. Hedvall[30] studied ferric oxide roasted at different temperatures. Parmelee, Badger, and Ballam[31] and Krause and Thiel[32] investigated the iron spinel. Hansen and Brownmiller[33] studied the system corundum–hematite. Bowen and Schairer,[34] Greig,[35] and Kleffner and Kohlmeyer[36] investigated the reactions which take place between silica and iron oxide.

II. Experimental Procedure and Data

As a working basis, the proportions of feldspar, clay, and silica used by Stull[37] in ten of his engobes were selected. The kaolins were North Carolina kaolin, A1 English china clay, and Edgar Georgia kaolin. Dorset English and Tennessee Special No. 1 ball clays were used.

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The batch of each mixture was blunged, aged, and applied to semivitreous tile by dipping. The tile were dried and one-half of each was dipped in Seger's porcelain glaze: whiting 70, feldspar 167, Edgar Florida kaolin 51.6, and potters' flint 108. The trials were fired in a gas-fired kiln to cone 10 down in 14 hours. All of the engobes were satisfactory.

(1) Coloration by Precipitation

The base composition of all engobes used in this investigation are given in Table I. Standard

TABLE I
BASE ENGOBE FORMULA

Series No.	N.C. kaolin	Ball clay	N.C. feldspar	Potters' flint	A1 English china clay
0	35	10	20	35	
1		10	35	30	25
2		10	50	15	25
3		10	35	30	25
4		10	35	30	25
5		10	35	30	25
6		10	35	30	25
8		10	35	30	25
11		10	55	10	25
12		10	60	10	20
13	20	10	60	10	
373	35	10	35	20	
15	25	10	45	20	
16	35	10	35	20	
17	20	10	60	10	
18	35	10	35	20	
21–1*	50	10	30	10	
21–9	10	10	60	20	
21–19	10	10	20	60	

* The 21 series was arranged in the form of a triaxial diagram.

ferric chloride solution was added to 100 grams of each engobe, and the iron was precipitated as the hydroxide with ammonia. With series Nos. 3, 4, and 5 (Table II), the carbonates were added after neutralization with ammonia because ferric chloride reacted with these compounds.

Additions to batches were made on the basis of 100 grams of the engobe mixture.

In the first trial, engobes of series Nos. 0, 1, 2, 3, 4, 5, 6, and 8 were used. All except No. 8 cracked either in drying or firing. The engobes of series 373 were dialyzed in viscose casings to remove the ammonium chloride formed during the precipitation of the ferric hydroxide. In some cases cracking was avoided. Because this cracking was due to the shrinkage of the hydroxides, a study was made of the drying behavior of iron and aluminum hydroxides. After the drying experiments were completed, engobes of series Nos. 373, 11, 12, 13, 15, 16, 17, 18, and 21 were prepared. All of these engobes were dried at 125° and then were reblunged. The engobes and glaze were applied in the usual manner and the tile were fired to cone 12. In most cases the colors were measured with a Lovibond tintometer.[38]

There was no cracking of any of the engobes. With series 373, the colors increased from a light buff with 1% to a reddish brown shade with 5% ferric oxide. Series 13 gave more intense colors, and fine reds were obtained with 5% ferric oxide. Series 12 was similar to No. 13, and No. 15 had characteristics lying between Nos. 373 and 13. There was some indication of the lightening of the normal shade due to iron with No. 16 in which aluminum hydroxide was precipitated. Good fits were obtained with all members of series 21. Those with a high clay content developed buff

[38] Color Measurement: Lovibond Tintometer. The Tintometer, Ltd., Salisbury, England.

TABLE II

Series	Additions													
0	0.5	1.0	2.0	3.0	5.0		Fe_2O_3							
1	0.5	1.0	2.0	3.0	5.0		"							
2	0.5	1.0	2.0	3.0	5.0		"							
3			2.0		5.0		"	0.5	1.0	2.0	3.0			% CaO from $CaCO_3$
4			2.0		5.0		"	0.5	1.0	2.0	3.0			% BaO " $BaCO_3$
5			2.0		5.0		"	0.5	1.0	2.0	3.0			% MgO " $MgCO_3$
6			2.0		5.0		"		1.0	2.0	3.0	4.0	5.0	% Al_2O_3 " $Al(OH)_3$
8	0.5	1.0	2.0	3.0	5.0		"	As dialyzed $Fe(OH)_3$						
11	0.5	1.0	2.0	3.0	5.0		"							
12	0.5	1.0	2.0	3.0	5.0		"							
13	0.5	1.0	2.0	2.5	3.0	5.0	"							
373	0.5	1.0	2.0	2.5	3.0	5.0	"							
15	0.5	1.0	2.0	2.5	3.0	5.0	"							
16			2.0	2.5	3.0	5.0	"		1.0	2.0	3.0	4.0	5.0	% Al_2O_3 from $Al(OH)_3$
17			2.0	2.5	3.0	5.0	"		1.0	2.0	3.0	4.0	5.0	% Al_2O_3 " "
18			2.0		3.0	5.0	"		1.0	2.0	3.0	4.0	5.0	% CaO " $CaCO_3$
21–1			2.0				"							
21–9			2.0				"							
21–19			2.0				"							

Except as otherwise noted, iron oxide was added as an equivalent amount of ferric hydroxide precipitated from ferric chloride.

colors, and a russet color was obtained with those which had a high feldspar content. Those with high silica gave reddish brown shades. The engobes of series 18, which contained both calcium oxide and iron oxide, gave peculiar colors. The presence of calcium oxide with high iron content tended to produce blacks. Magnesium and barium oxides behaved in a manner similar to calcium oxide.

Some of the engobes were fired to cones 6 and 9. A fritted lead glaze known as Mayer's glaze[39] was applied and the tile were refired at cones 2 to 3.

(2) Study of Water-Loss of Aluminum and Ferric Hydroxides During Drying

The hydroxides were precipitated from chlorides of aluminum and iron by ammonia and then were dialyzed to remove the ammonium chloride formed by the reaction. Samples of about one gram in weight on the dry basis were dried in air, placed in desiccators over calcium chloride to constant weight, and then in an electric drier. One sample of each of the hydroxides was removed each day, weighed, and the temperature was increased. At 189° the ferric hydroxide had lost practically all of its water, while the aluminum hydroxide had lost about one-half of the water. After drying in this manner, they were soaked in water for three days and then were redried. The water-loss for the aluminum hydroxide, dried at 189° and then soaked and redried, was 7.80%, while that of the ferric oxide was 6.90%. These results show that these hydroxides are, to a certain extent, irreversible. It was found in practice that drying at 125° prevented the cracking of the engobes in drying and firing.

(3) Adsorption of Ferric Hydroxide Sols

After the ferric hydroxide sols were prepared by the hydrolysis of ferric chloride in boiling water, they were analyzed for iron.* These sols had the following contents of iron in grams per liter: 0.100, 0.455, 0.897, 1.978, 2.980, 3.967, and 5.945.

Two methods were used for studying adsorption. With the first, 7.5 grams of clay previously dried at 100° were added to 150 milliliters of the sol and the slurry was agitated for 20 minutes. The suspension was filtered through a Buchner funnel, and after a clear filtrate had been obtained, two 50-milliliter portions of the filtrate were analyzed for iron. From these analyses, the amounts of total iron adsorbed by these materials could be calculated. With the second method, the clays or other materials were mixed with the sol as before, but the suspension was allowed to stand in glass-stoppered graduates. The supernatant liquid was removed and analyzed for iron. In general, the adsorption was less by the second than by the first method. It is probable that with the first method, the filter paper adsorbed some of the iron compounds. The adsorption characteristics of Edgar Florida kaolin, A1 English china clay, special Tennessee ball clay No. 1, Dorset English ball clay, tripoli, potters' flint, and feldspar were investigated by both methods.

The efficiency of adsorption was calculated from Freundlich's adsorption isotherm, which is $x/m = KC^n$, where x/m is the weight adsorbed per gram of adsorbent and C is the concentration after equilibrium has been attained; then x/m divided by C is the efficiency of the process. The results of the experiments do not follow exactly the equation as given by Freundlich, but the efficiency of adsorption decreases markedly with increase of iron concentration of the sol and this is in agreement with Freundlich's equation. Both kaolins and ball clays will adsorb iron compounds from such sols but the amount is not great. Florida kaolin adsorbs more than the other clays. Potters' flint, tripoli, and feldspar will adsorb very little of these compounds from these "colloidal" solutions.

The adsorption experiments were continued with the use of Graham's dialyzed and Pean St. de Gilles' ferric acetate sols. The former was prepared by adding standard ferric chloride solution to boiling water, after which it was cooled and thoroughly dialyzed in viscose casings. The analysis showed that it contained 2.428 grams of iron per liter. Pean St. de Gilles' sol was formed by adding ferric acetate solution to water and boiling for three hours in a Florence flask with a reflux condenser attached. The sol was stable, brick red in color, and contained 2.965 grams of iron per liter.

[39] C. W. Parmelee, "Outlines of Essentials of Glaze Composition," p. 63C. Compilation of glaze studies in mimeographed form, 86 pp., 1929.

* The potassium-dichromate method with sodium diphenylamine sulfonate as the internal indicator was used for all analyses of iron. (For this method, see H. H. Willard and N. H. Furman, Elementary Quantitative Analysis, p. 199, 2d ed. D. Van Nostrand Co., Inc., New York. 416 pp., 1935.)

The same raw materials were used as in the previous adsorption experiments. Five grams of each of these were thoroughly stirred for 20 minutes with 100 milliliters of the sols and allowed to stand for two weeks in glass-stoppered graduates. The supernatant liquid was then analyzed for iron. Florida kaolin and tripoli adsorbed practically all of the colloidal ferric hydroxide from both the Graham and the Pean St. de Gilles' sols. The other materials did not adsorb the sols to any great extent.

The results indicate that to color an engobe satisfactorily by adsorption of colloidal ferric hydroxide, such an engobe should consist essentially of tripoli, Florida kaolin, and feldspar. Eleven engobes containing these constituents were prepared and fired at cone 11. While not one of them was particularly satisfactory, the best two were selected for further study. One of these had a composition of 25% Florida kaolin, 25% tripoli, and 50% feldspar, and the other, 25% Florida kaolin, 40% tripoli, and 35% feldspar.

Graham's dialyzed sol having an iron content of 4.57 grams per liter was measured into a beaker, 100 grams of the engobe were added, and the mixture was stirred and allowed to settle. The supernatant water was clear and was removed with a siphon. Ferric hydroxide, corresponding to 0.5, 1, and 2% of ferric oxide, was added in this manner to each of the engobes and these were applied to semivitreous tile, after which they were fired at cones 10 to 12. No pleasing colors were obtained, and a microscopic examination showed that the particles of iron oxide were larger than when a like amount of iron was added by precipitation of ferric hydroxide.

(4) Coloration of Engobes by Direct Additions of Red Iron Oxide

In this method, the engobes were weighed in the proper proportions, and the red iron oxide or basic ferric acetate was added. Series 9 corresponded with series 1 (Tables I and II), except that the iron was added in the form of basic ferric acetate. Series 10, 19, 20, and 29 corresponded to series 1, 373, 13, and 21, respectively, except that the iron in the former group was added as an equivalent amount of commercial red iron oxide.

The results were not so satisfactory as when the iron was added by precipitation, and there was a tendency for gray shades to appear with Nos. 9, 10, and 19. With No. 20, which contained a high percentage of feldspar, the colors were similar to those of No. 13, in which the iron was precipitated as the hydroxide.

(5) Coloration by Ferric Hydroxide Precipitated in a Silica Gel

Sodium silicate (alkali-silica ratio 1 to 3.25) was diluted with three parts of water and neutralized with dilute ferric chloride. The gel thus formed was thoroughly dialyzed to remove the sodium chloride formed in the reaction and the excess ferric chloride. A chemical analysis of the gel, previously dried at 110°, showed that one gram of the dried gel contained the equivalent of 0.1633 gram of ferric oxide. The base engobe was No. 373 (Table I); amounts of silica gel that would supply 0.5, 1, and 2% ferric oxide were added and the mixtures were ground with water for one hour in a pebble mill. The engobes were applied to tile and were fired to cones 8 and 12. Pink colors were obtained with the engobes which contained 1 and 2% ferric oxide and were fired at cone 8. The colors became brown with an increase in firing temperature.

(6) Coloration by Calcines

(*a*) A series of calcines was prepared from potassium nitrate, aluminum hydroxide, and silica. The molecular ratios of these varied from $K_2O \cdot Al_2O_3 \cdot SiO_2$ to $K_2O \cdot Al_2O_3 \cdot 5SiO_2$, with a difference of one mole of silica in each successive calcine. These mixtures were calcined at cone 16 for five hours and were ground to pass 200-mesh. The only well-sintered calcine was the last in the series with 5 moles of silica; not one of the engobes was satisfactory.

(*b*) The nitrate solutions of alumina and iron were mixed, heated, and neutralized with ammonia. The hydroxides were dialyzed for two days in running water, calcined at 1000°, and ground to pass 115-mesh. Twenty-five grams of each of six calcines were prepared with the following molar ratios of iron oxide to alumina: 1:1, 1:2, 1:3, 2:1, 1:4, and 4:1. The base engobe was No. 373 (Table I). The calcines were added in such proportions that each engobe had an addition of 1, 2, and 3% of iron oxide. The engobes were ground with water in a porcelain pebble mill for one hour and were applied in the usual manner. They were fired at cones 9 and 12.

The colors were not as uniform as when the

iron was added by precipitation. Calcines which had a high alumina content produced buff colors while those with a high iron content were gray.

(7) Calcines of Ceramic Materials Containing Iron Oxide

A series of calcines was prepared with ceramic materials in which iron hydroxide was precipitated from a ferric-chloride solution by ammonia. Most of the ammonium chloride formed in the reaction was removed by dialysis. The ignition losses of the clays and aluminum hydrate were obtained, and the iron hydroxide was precipitated on the basis of the ignited weights of the clays and aluminum hydrate, allowance being made for the iron present in the raw clays. A silica gel was prepared by the neutralization of sodium silicate with hydrochloric acid, then dialyzed, ground wet and washed with distilled water; it was then dried at 110°, ground to pass 200-mesh, and the ignition loss was determined. The mixtures prepared are shown in Table III.

TABLE III

Calcine No.	Materials
1, 2, 3, 4	Potash feldspar and ferric oxide
5, 6, 7, 8	A1 English china clay and ferric oxide
9, 10, 11, 12	Tripoli and ferric oxide
13, 14, 15, 16	Commercial potters' flint and ferric oxide
17, 18, 19, 20	Aluminum and ferric hydroxides co-precipitated
21, 22, 23, 24	Florida kaolin and ferric oxide
25, 26, 27, 28	North Carolina kaolin and ferric oxide
29, 30, 31, 32	Commercial aluminum hydrate and ferric oxide
33, 34, 35, 36	Potters' flint ground 12 hours and ferric oxide
37, 38, 39, 40	Silica gel and ferric oxide

The amount of iron hydroxide added (precipitated in each mixture) corresponded to 2, 5, 10, and 15% of ferric oxide for each material.

These were heated at 1000° for one hour in an electric muffle furnace, and some of them were calcined in a Globar furnace at 1215°. The colors were measured with a Lovibond tintometer.

Those calcines having potters' flint as a base and calcined at 1000° (Nos. 13 to 16) had colors similar to those containing feldspar fired at 1000°C. A comparison of mixtures containing potters' flint (Nos. 13 to 16), tripoli (Nos. 9 to 12), potters' flint ground for 12 hours (Nos. 33 to 36), and silica gel (Nos. 37 to 40) showed that commercial potters' flint gave the most intense coloration.

North Carolina kaolin gave a darker color than Florida kaolin, and the grain size of the former is the larger of the two.

The colors of calcines with commercial aluminum hydrate are different from those with aluminum hydrate because the grains of the latter are colored throughout, and in the commercial aluminum hydrate there is a mixture of iron oxide and aluminum hydrate particles.

III. Microscopic Examination of Engobes and Calcines

The microscopic examinations were made on immersed grains and magnifications of 500 to 800 diameters were used.

(1) Calcine No. 2 (feldspar with 5% ferric oxide) was not melted at 1000° and showed aggregates of hematite surrounding the unmelted feldspar. When heated at 1215°, the feldspar melted, but there was no reaction with the iron oxide and the color was an intense red.

(2) Calcine No. 6 (A1 English china clay with 5% ferric oxide), fired in air at 1000° and 1215°, showed small grains and aggregates of hematite interspersed among the clay particles. When fired at 1215° in nitrogen, the hematite was reduced and the clay aggregates were a brownish yellow. Small particles of finely divided magnetite are also of this color.

(3) Calcine No. 14 (commercial potters' flint with 5% ferric oxide), when fired at 1000°, had practically the same color as feldspar containing the same amount of iron oxide and fired at the same temperature. At 1215° there was some aggregation of iron-oxide particles.

(4) Calcine No. 38 (silica gel with 5% ferric oxide), when heated, showed some colorless grains and others with small inclusions of ferric oxide. The color was light buff when fired at 1000°, but became darker at 1215° because there was considerable shrinkage of the silica gel.

(5) Calcine No. 18 (5% ferric oxide co-precipitated with aluminum hydroxide) showed little difference when fired to 1000° or 1215°. The grains were a light brown and these contained cryptocrystalline particles of corundum. No iron spinel was noted.

(6) Calcine No. 30 (commercial aluminum hydrate with 5% ferric oxide) was fine grained and the hematite particles were dispersed among the alumina particles.

(7) Very pure ferric oxide was prepared by roasting ferrous sulfate at red heat. The material became sintered and black in color when fired in air at 1215°, but a microscopic examination

showed that the iron oxide was in the form of hematite. Greig, Posnjak, Merwin, and Sosman[23] have pointed out that all grains of hematite are not of the same color and may be darker than usual due to physical inhomogeneities and because of the high birefringence of hematite; a grain that is composed of parts with different orientations appears darker than normal when seen in transmitted light. They also found that if hematite is heated, the grains become larger and more compact. The writers found that if hematite was heated to 1215° the crystals were much larger than if heated at a lower temperature.

(1) Engobes with Silica Gel in Which Ferric Hydroxide Was Precipitated

The iron oxide particles were well distributed and red when the engobe was fired at cone 8. These grains were in a matrix of an isotropic material, presumably silica gel, and the individual particles of the iron oxide were very small, being less than one micron in diameter and arranged like fish roe. The color of those engobes, containing 1 and 2% ferric oxide, fired at cone 8, was an orchid shade, but became brown when fired at cone 9 or higher.

(2) Engobes with a High Percentage of Feldspar

With firing temperatures corresponding to cone 8, the individual particles of ferric oxide were small and were surrounded by particles of feldspar glass. At cone 12, there had apparently been a slight reduction of the iron oxide. There was no sign of solution or reaction of the hematite with the glass.

(3) Engobes with Calcium Oxide and Ferric Oxide

Where the Seger glaze was used with engobes having a high iron content, the glaze became dark at high temperatures of firing. An examination of several of these engobes showed that the iron oxide particles were very black in color, but there were no signs of the formation of new compounds.

(4) Engobes with Direct Additions of Commercial Red Iron Oxide

There was no evidence of any reaction between the iron oxide and the other ingredients of the engobes. The iron oxide particles were black and opaque, except on the edges, where they were red, and when the larger aggregates were crushed, all of the fine particles were red; the engobe was gray.

(5) Engobes with High Clay Content

These engobes (No. 21–1) have a tendency toward buff colors, and if the iron oxide content is kept at 2%, excellent buffs are obtained. This color is due to the large number of clay particles in comparison with the number of hematite grains present in such engobes.

(6) Engobes with High Silica Content

The color tends toward brown and the iron-oxide particles were grouped around the grains of quartz which were comparatively large as contrasted with the clay grains in the engobe (No. 21–1). There was no evidence of any reaction, but there was an increase in size of the hematite particles with increased firing temperatures.

IV. Effect of Furnace Atmosphere

The engobes were applied to small pieces of semivitreous tile and all were given a preliminary firing at red heat to volatilize the ammonium chloride. A "Sentry" high-temperature Globar tube furnace was used and the temperatures were measured with a precision potentiometer in conjunction with a calibrated Chromel-Alumel thermocouple. Nitrogen, oxygen, air, and carbon monoxide were passed through the furnace.

Commercial nitrogen was passed through the train recommended by Bowen and Schairer.[24]

Commerical oxygen was passed through the train devised by Hostetter and Sosman,[25] except that rubber tubing instead of glass seals was used.

Suction—bubbling bottle—safety trap—calcium chloride tower—Globar furnace—calcium chloride tower—bubbling bottle with sulfuric acid were used for air.

For carbon monoxide, a gas generator—bubbling bottle with sulfuric acid—calcium chloride tower—Globar furnace—bubbling bottle—hose to outside of building were used. The gas generator consisted of a flask in which formic acid was placed, the sulfuric acid being introduced through a separatory funnel. This worked satisfactorily as the rate of reaction between the sulfuric and formic acids at room temperature is very slow.

Engobes Nos. 373, 13, 21–1, and 21–19 (Tables I and II) with ferric hydroxide equivalent to 2 and 5% iron oxide were used. All were fired at 1105° and 1215° in atmospheres of oxygen, nitrogen, and air; engobes Nos. 13 and 373 were fired in an atmosphere of carbon monoxide at 600°, 800°, and 1050°.

In general the colors were a little more brilliant when the engobes were fired at 1215° in an oxygen atmosphere than when fired in air at the same temperature. They were greatly reduced when fired in a carbon monoxide atmosphere and also when fired in a nitrogen atmosphere at 1215°.

V. Summary and Interpretation of Results

(*a*) The most satisfactory method for adding iron oxide is to precipitate the iron in the engobe as the hydroxide, because uniform colors are obtained. The dispersion of the iron oxide is not so great as with naturally occurring clays, but the results are satisfactory.

(*b*) Unusual effects are procured by using a silica gel in which ferric hydroxide had been precipitated because orchid shades are obtained which are unlike colors produced by any other method.

(*c*) Direct addition of commercial red iron oxide causes specks due to the large particle size of the ferric oxide.

(*d*) Very dark gray colors are obtained in certain engobes with a moderate feldspar content, although the iron oxide is in the ferric form. The effect is due to the crystal growth of the hematite. Where commercial iron oxide is added to engobes with a high feldspar content, fairly satisfactory red colors are obtained.

(*e*) The addition of iron hydroxide by adsorption is not satisfactory as the particle size of the iron oxide grains is rather large. The presence of tripoli in the engobes causes them to have rough surfaces.

(*f*) With calcined mixtures of co-precipitated aluminum and ferric hydroxides, those with a high iron content produce grays, while those with a high alumina content give buff colors. These differences are due to the colors of the individual calcines and not to the total amount of iron present since this is kept constant.

(*g*) The composition of the engobes is one of the important factors in the production of colors, and these colors depend to a marked extent upon the fineness of division of the particles, and upon the fusibility of the feldspar. It has been shown that coarse-grained clays, like North Carolina kaolin, give a more intense color than fine-grained clays of the Florida type and that ground potters' flint gives a lighter color than the commercial product when like amounts of iron hydroxide are precipitated in them and the mixtures are calcined.

(*h*) Clays give a lighter coloration than commercial potters' flint when the same amount of iron hydroxide is precipitated with them and the mixtures are heated. This is due to the difference in particle size of the two materials because, within the limits of this investigation, there is no evidence of chemical reactions taking place between clays or potters' flint with red iron oxide.

(*i*) Feldspar does not combine with the iron oxide within the limit of these experiments. The particles of iron oxide are surrounded by the feldspar glass which decreases surface reflections from the hematite and thus enhances the red color of the hematite.

(*j*) To obtain buff colors, a high clay content is advisable; if browns are desired the quartz content should be high, and for good red colors the feldspar content should be about 60%.

(*k*) Greig, Posnjak, Merwin, and Sosman[23] reported that practically pure hematite is stable at 1378° when heated in a stream of air. Within the limits of this investigation, the only possible changes in the ferric oxide by temperature alone in air are an increase in the size of the hematite crystals or an agglomeration of the same. These changes have been shown to take place by a study of ferric oxide heated at 1215° in a stream of air.

(*l*) The exact knowledge of the reduction and oxidation of iron oxide can not be given by a measurement of excess air in firing unless the partial pressure of the oxygen in the flue gas is calculated. If the oxygen pressure in the combustion gases is greater than the dissociation pressure of ferric oxide, oxidation would be expected to prevail. The recent work of Greig, Posnjak, Merwin, and Sosman[23] places the dissociation pressure of the oxygen in hematite at approximately two millimeters at 1200°. A natural gas with the composition 90% methane, 5% ethane, and 5% nitrogen, fired with 20% excess air, will have a partial pressure of the oxygen corresponding to 23 millimeters of mercury; thus at 1200° oxidizing conditions would occur, but at some higher temperature the partial pressure of the oxygen from the hematite would be above this value and consequently the iron oxide would be reduced.

(*m*) With engobes fired in the Globar furnace, it is more certain that oxidizing conditions pre-

vailed than in the gas-fired kiln. The iron oxide present in engobes fired at 1215° in the Globar furnace in a nitrogen atmosphere was reduced and this reduction brought out the coloring power of the iron. The finely divided magnetite is yellow-brown in color, and it is thus possible to produce tan colors under reducing conditions.

Acknowledgment

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INFLUENCE OF COMPOSITIONS OF UNDERSLIPS, GLAZES, AND BODIES ON BLISTERING AND OTHER GLAZE DEFECTS*

By H. G. Schurecht† and J. F. McMahon‡

Abstract

The adhesion between underslip and body or glaze is frequently broken in spots as a result of air being forced to the surfaces during the spraying of successive wet coats of slip or glaze. These breaks, which do not always heal in firing, develop defects known as blisters, pinholes, and round bare spots. This tendency may be reduced (1) by increasing the percentage of plastic clay in the underslip; (2) by spraying the underslip thinner; (3) by selecting more suitable ball clays; (4) by changing the raw materials and compositions of glazes; and (5) by using coarse in place of fine-grained bodies. It was found that blistering developed on bisque as well as on raw bodies. Many correlated glaze defects not visible on the dry specimens first appear after firing.

I. Introduction

Sprayed underslips or glazes adhere to the body. On breaking a dry piece of sprayed ware, the fracture seldom develops between the slip and the body; it usually follows the same plane as that of the body. This adherence makes it possible to produce a uniform glaze over a ceramic body and also keeps the glaze and body united while shrinking in the early stages of firing and in early fusion when molecular attraction tends to draw the slip from the body. A thin slab of raw glaze dried and placed on a body does not unite to the body uniformly but, when fired, tends to ball up.

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Table I

Compositions of the Underslips

	1A	1B	1C	1D	1E	1F	1G	1H	1I	1J	1K	1L	1M	1N	1O	1P	1Q
English china clay	32.5	22.5	32.5	32.5	32.5	32.5	32.5		40.0	33.2	25.0		20.0	19.0	15.0	32.5	
Ball clay (1)	20.9	20.9								8.9	20.0	25.0		19.0			15.3
Ball clay (2)			20.9										20.0		15.0		
Ball clay (3)				20.9													
Ball clay (4)					20.9												
Ball clay (5)						20.9											
Ball clay (6)																20.9	
Ball clay (7)							20.9										
Monmouth clay								100	40.0	22.1		30.0					
Calcined kaolin																	19.1
Cornwall stone	41.0	41.0	41.0	41.0	41.0	41.0	41.0			19.9	45.0	45.0	30.0		35.0	41.0	34.3
Buckingham feldspar									20.0	11.0				35.7			
Whiting		10.0												7.0			
Flint	5.0	5.0	5.0	5.0	5.0	5.0	5.0			4.4	10.0		30.0	19.0	35.0	5.0	7.6
Zircopax																	22.9
Soda ash	0.6	0.6	0.6	0.6	0.6	0.6	0.6			0.5				0.3		0.6	0.8
(1)	53.4	43.4	53.4	53.4	53.4	53.4	53.4	50.0	60.0	53.1	45.0	40.0	40.0	38.0	30.0	53.4	15.3
(2)	46.6	56.6	46.6	46.6	46.6	46.6	46.6	50.0	40.0	46.9	55.0	60.0	60.0	62.0	70.0	46.6	84.7
(3)	1.14	0.77	1.14	1.14	1.14	1.14	1.14	1.00	1.50	1.13	0.82	0.67	0.67	0.61	0.43	1.14	0.18

(1) = plastic material.
(2) = nonplastic material.
(3) = ratio of plastic to nonplastics.

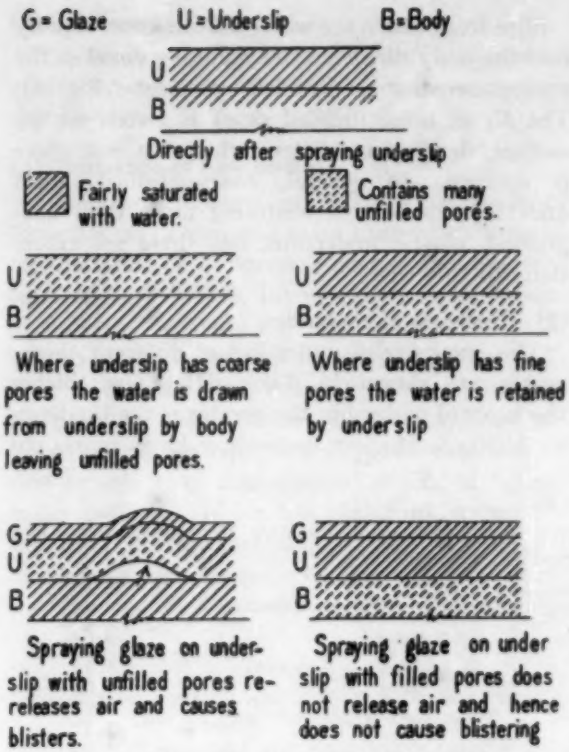
G = Glaze
U = Underslip
B = Body
U
B
Directly after spraying underslip
Fairly saturated with water.
Contains many unfilled pores.
Where underslip has coarse pores the water is drawn from underslip by body leaving unfilled pores.
Where underslip has fine pores the water is retained by underslip
G
Spraying glaze on underslip with unfilled pores releases air and causes blisters.
Spraying glaze on underslip with filled pores does not release air and hence does not cause blistering

FIG. 1.—Glaze defects originating in spraying.

Many glaze defects originate from air bubbles causing failure of the glaze to adhere in spots (see Fig. 1). Where release of air during spraying is violent, blisters may develop.[1] This defect is most marked when the interval of time between application of the successive coats of underslip and glaze is long, *i.e.*, 5 to 10 minutes. Many blisters are $^1/_{16}$ to $^1/_8$ inch in diameter, but freshly sprayed glazes will have many small pinholes 0.050 to 0.002 to 0.010 inch in diameter.

In still other cases the bond is broken between the glaze and body but no blisters are formed; the defect is observed only after the ware has been fired.

II. Materials and Methods

The compositions of the underslips used in this work are shown in Table I. Three coats of underslip were sprayed on raw clay tile, 2 by 4 by 1 inch, previously dried at 110°C. They were applied to the tile with as little time between coats as possible. An interval of ten minutes, however, was allowed before applying the first coat of glaze and then it was inspected for blisters. This long interval of time between spraying the underslip and glaze accentuates blistering. Second and third glaze coats were applied after five-minute intervals and inspected for blistering. The thickness of underslips was varied on other sets.

The compositions of underslips 1A, 1C, 1D, 1E, 1F, 1G, and 1P differed only in the ball clay used.

In other series, the glazes were sprayed directly on the body allowing five-minute intervals between the successive coats.

The compositions of the glazes used were as follows:

2B (Alkali lead borax glaze)

	Frit	Mill batch	
Calcined borax	50.5 parts	307.0 parts frit	
Whiting	35.0 "	25.0 "	Ga. kaolin
Lead oxide (PbO)	89.2 "	22.6 "	tin oxide
Ga. kaolin	25.9 "		
Flint	126.0 "		

2H (Raw lead glaze)

	(%)
White lead	39.40
Buckingham feldspar	34.73
Whiting	3.05
Zinc oxide	2.44
Magnesium carbonate	2.59
Kaolin	2.44
Flint	10.80
Tin oxide	4.55

2J (Lead-free borax zinc glaze)

	(%)
Titanium alloy 15693 B frit	120.9
Buckingham feldspar	89.4
Whiting	20.0
Georgia kaolin	20.6
Flint	46.2
Tin oxide	30.2

2Q (Raw colemanite glaze)

	(%)
Calcined zinc oxide	24.3
Buckingham feldspar	119.2
Colemanite	41.2
Barium carbonate	59.1
Flint	102.6
Tin oxide	22.7

Separate sets of tile were made of Monmouth clay, Kentucky ball clay, Georgia kaolin, and Binghamton shale.

The underslips and glazes were also applied to bisque bodies.

III. Discussion of Results

(1) Different Underslips

In Table II, the underslips are arranged in order of their ability to resist blistering; Nos. 1I and 1O produced excessive blistering while

[1] H. G. Schurecht, "Blistering and Crawling of Glazes Caused by Underslip," *Jour. Amer. Ceram. Soc.*, **17** [6] 182–84 (1934).

Nos. 1E and 1H did not blister, owing probably to differences in their ability to retain water.

It has been shown[2] that as the plasticity of the clays is lowered their permeability to water is increased. The capillary attraction of water may be represented by the following formula:

$$H = \frac{2Y}{grd} \qquad (1)$$

H = capillary height (cm.)
g = 981 gravitational acceleration (cm./sec.^{2})
r = radius of capillary tube
d = density of liquid at temperature of observation
Y = surface tensions (dynes/cm.).

As the value, r, is increased the capillary attraction is lowered. By raising the nonplastics in the underslip, the average value for r is increased and its capillary attraction and ability to retain water is decreased. Conversely, with an increase in plastic clay content, capillary attraction is increased, permeability to water is decreased, and the ability of the underslip to retain water is improved.

[2] H. G. Schurecht, "Mechanical Movement of Water through Certain Clays and Its Control," *Jour. Amer. Ceram. Soc.*, **5** [12] 928–36 (1922).

Slips from which the water diffuses most rapidly into the body directly after spraying develop the greatest amount of unfilled pores (see Fig. 1). The air in these unfilled pores is forced to the surface, developing blisters when the wet glaze is sprayed. In general, coarse-grained, short underslips cause this blistering more than fine-grained, plastic underslips, but there are exceptions to this rule.

(2) Thickness of Underslip

The results with underslips of different thicknesses are shown in Table III. The thicker the layer of underslip, the greater is the tendency to blister. Thicker underslips have more unfilled pores; therefore, more air is forced to the surface when a wet glaze coat is sprayed on.

(3) Ball Clays in Underslips

Ball clays Nos. 4 and 1 proved decidedly better than Nos. 7 and 5. This difference is probably due to the fact that some ball clays are finer grained than others and are more capable of retaining water.

TABLE II

TENDENCY OF DIFFERENT UNDERSLIPS TO DEVELOP BLISTERS DURING SPRAYING ON RAW MONMOUTH CLAY TILE
(Underslips were sprayed 44°–47°Bé)

Slip Nos.	Thickness of underslips (in.)	Tendency to develop blistering during spraying			Thickness of glaze (in.)	Ratio of plastic to non-plastic in underslip
		1st coat	2nd coat	3rd coat		
1E	0.012	None	None	None	0.016	1.14
1H	.011	"	"	Slight	.016	1.00
1L	.009	"	"	"	.015	0.67
1A	.016	"	"	Bad	.009	1.14
1C	.012	"	Slight	"	.012	1.14
1B	.012	"	Few	"	.018	0.77
1D	.015	Slight	Moderate	"	.011	1.14
1J	.014	"	"	"	.016	1.13
1K	.013	None	Bad	"	.016	0.82
1Q	.009	Slight	"	"	.013	0.18
1P	.013	"	"	"	.011	1.14
1G	.004	Moderate	"	"	.014	1.14
1N	.015	Slight	"	"	.012	0.61
1F	.017	Bad	"	"	.019	1.14
1M	.011	Moderate	"	Very bad	.014	0.67
1I	.011	Bad	"	" "	.021	1.50
1O	.016	"	"	" "	.014	0.43

TABLE III

INFLUENCE OF THICKNESS OF UNDERSLIP ON TENDENCY OF GLAZES TO DEVELOP BLISTERING DURING SPRAYING ON RAW SYRACUSE CLAY TILE
(Underslip 1F was used)

No. of coats of underslip	Thicknesses of underslip (in.)	Tendency to develop blisters during spraying			Thickness of glaze (in.)
		1st coat	2nd coat	3rd coat	
1	0.0062	None	Moderate	Very bad	0.013
2	.0100	Slight	Bad	" "	.015
3	.0150	Very bad	Very bad	" "	.019

(4) Different Glazes

The results obtained with different glazes when sprayed on raw clay tile without using an underslip are shown in Table IV.

(5) Influence of Raw Bodies

Glazes which were sprayed on tile made of Syracuse clays blistered more than when sprayed on tile made of Monmouth clay. This observation led to a further investigation of the effects of different bodies on their tendency to create blistering. The results are shown in Table V.

It is obvious that coarse-grained bodies like Binghamton shale, which has low capillary attraction and high permeability, develop less of this trouble than finer-grained bodies like Kentucky ball clay, which has high capillary attraction and low permeability. The body should have properties opposite to those of the underslip to produce the least amount of blistering.

TABLE IV

TENDENCY OF SOME GLAZES TO BLISTER DURING SPRAYING ON RAW MONMOUTH TILE

(No underslip was used and glaze was sprayed at five-minute intervals between coats)

	Tendency to develop blisters during the spraying of glazes		
	1st coat	2nd coat	3rd coat
2B	None	Slight	Bad
2H	"	None	"
2J	"	Moderate	Moderate
2Q	"	None	"

(6) Bisque Compared with Raw Bodies

In general, underslips which showed the least resistance to blistering on unfired specimens also displayed similar results on the bisque specimens.

FIG. 2.—Sketches showing formation of blisters in spraying.

Bisque ware shows a somewhat less tendency to produce blisters than unfired bodies although the difference is not great.

(7) Influence of Spraying Defects on Fired Glaze Defects

Blistering and other defects increased in number and size on the fired ware as compared with unfired samples. It is evident that spraying

TABLE V

EFFECT OF DIFFERENT BODIES ON TENDENCY OF GLAZES AND UNDERSLIPS TO DEVELOP BLISTERING DURING SPRAYING

Clay body	Underslip and glaze	Coats of slip and glaze	Tendency to develop blisters during sprayings		
			Trial 1	Trial 2	Trial 3
Kentucky ball clay	Underslip 1J	1	None	None	None
		2	"	"	"
		3	Moderate	Moderate	Moderate
	Glaze 2H	4	"	"	None
		5	"	"	Bad
		6	Bad	Bad	"
Georgia kaolin	Underslip 1J	1	None	None	None
		2	"	"	"
		3	Moderate	Moderate	Moderate
	Glaze 2H	4	Slight	"	"
		5	Moderate	"	"
		6	Unchanged	Bad	Bad
Syracuse clay	Underslip 1J	1	None	None	None
		2	"	"	"
		3	"	"	"
	Glaze 2H	4	Slight	"	Slight
		5	"	Slight	"
		6	"	"	Moderate
Binghamton shale	Underslip 1J	1	None	None	None
		2	"	"	"
		3	"	"	"
	Glaze 2H	4	"	"	"
		5	"	"	"
		6	"	Slight	"

causes many imperfections in the bond which are not apparent until the ware is fired.

The defects on fired glazes which originated from spraying imperfections were of two distinct types. One was a blister which originated under the underslip and in which the slip was actually lifted from the body. The other type of imperfection was circular bare spots $^1/_{64}$ to $^1/_{16}$ inch in diameter in which the underslip was exposed. These defects probably originated from incipient blisters between the underslip and glaze, in which case the glaze was separated from the underslip during spraying, and in firing it crawled from these portions of the underslip. It appears, therefore, that the inclination of underslips and glazes to develop blistering is responsible for more glaze defects than one would suspect from an examination of the freshly sprayed ware.

IV. Summary

(1) Using more plastic clays in underslips tends to overcome blistering and pinholing during spraying because it changes the relative capillary attraction and permeability of body and underslip to water.

(2) Blistering is accentuated by spraying the underslip too thick.

(3) Certain ball clays cause more blistering than others when used in an underslip, probably due to their different water-retaining abilities.

(4) Glazes sprayed directly on a body without an underslip may develop blistering; the amount is governed largely by the properties and proportions of the raw materials used.

(5) If successive coats of underslip or glaze are sprayed as soon as the wet sheen disappears from the previous coat, no blistering will develop, but if the intervals between coats are increased to five or ten minutes, excessive blistering may occur.

(6) The structure of the body influences spraying defects. Fine-grained plastic bodies produce more blistering than coarse-grained short bodies.

(7) Spraying underslips and glazes on bisque ware develops blistering almost as much as spraying on raw bodies.

(8) Many glaze defects originating during spraying first become apparent after firing.

Acknowledgment

This work was done as a portion of the program on changing the color and surface finish of heavy clay products, which was suggested for research by the Heavy Clay Products Division of the Ceramic Association of New York. The writers also wish to acknowledge their indebtedness to M. E. Holmes for useful guidance during the progress of the work.

EVAPORATION BY SUBMERGED COMBUSTION: VI, DEWATERING CLAY SUSPENSIONS*

By Kenneth A. Kobe, Hewitt Wilson, and Thomas M. Sheehy†

Abstract

Submerged combustion methods are described and their advantages are discussed. The application of this method to the dewatering of highly colloidal kaolins has been made. Evaporation takes place with thermal efficiencies up to 96% and evaporation efficiencies up to 85%. There is no difficulty with the clay until concentrations above 45% solids are reached. Hard particles then form owing to insufficient agitation. The solids content has been carried to 67%.

I. Introduction

The success with which submerged combustion has been used in heating and evaporating showed that it might be useful in dewatering highly colloidal clays.

* Received February 10, 1937.

† The authors of this paper are from the University of Washington, Departments of Chemical and Ceramic Engineering, Seattle, Wash.

II. Submerged Combustion

(1) Submerged Combustion Defined

Submerged combustion is the burning of a fuel-air mixture in such a manner that the combustion chamber is entirely surrounded by the liquid being heated, and the hot products of combustion pass through the liquid so that heat is transferred from the hot gases directly to the liquid. Fuel

gases and fuel oils are used. Gas equipment has been developed to a point of considerable use; oil-burning equipment is still in the experimental stage. The combustion chamber in which the gas-air mixture ignites need not be large enough for complete combustion to occur within the chamber, but it should be of such size to maintain a flame that will ignite the combustible mixture. The flame actually is forced out into the liquid by the flow of gas and air to the combustion chamber.

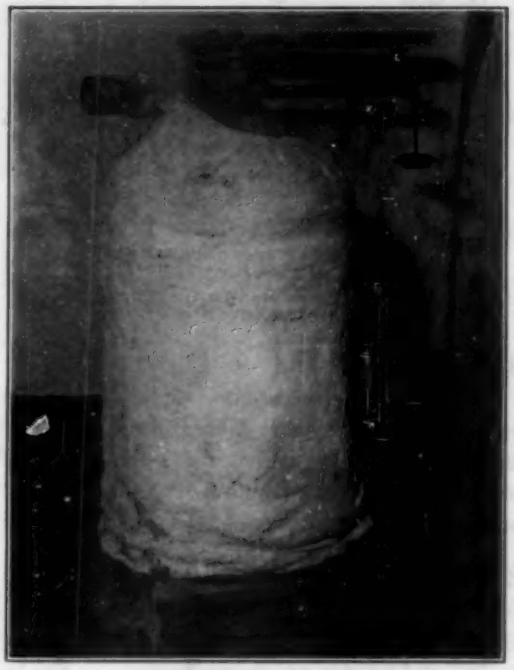

FIG. 1.—Evaporator and burner used.

(2) Equipment

A complete description of commercial submerged combustion equipment has been given.[1] The essential parts of a burner for gaseous fuel are compressors for gas and air, a mixing chamber, a velocity tube, and a combustion chamber. The gas and air must be compressed sufficiently to overcome the frictional resistance of the apparatus and the hydrostatic head of the liquid in which the burner is immersed. The gas and air must be mixed to give an entirely homogeneous gaseous mixture in which combustion will occur uniformly and completely. Because of this homogeneous mixture, the amount of excess air used for the combustion may be greatly reduced compared with ordinary combustion, and a reducing atmosphere may be maintained if necessary.

In industrial use in England, the Hammond burners contain the mixing chamber, velocity tube, and combustion chamber; thus separate lines bring the gas and air to the burner. In the small Kemp burner, the gas and air are mixed in a carburetor and the combustible mixture is piped to the burner, making necessary the use of explosion safeguards in the lines.

When a combustible mixture of gas and air is burned, the flame moves through the mixture at a definite rate which is the rate of flame propagation. It is necessary that the gas mixture be supplied to the combustion chamber at a velocity greater than the rate of flame propagation. Thus the velocity tube must be small enough that the flame can never pass back into the mixing chamber. In the Hammond burner, this is accomplished by means of an annular orifice; in the Kemp burner, by a perforated refractory dish. The Hammond burner has a large refractory-lined combustion chamber in which heat radiated from the refractory insures complete combustion. The gases may be ignited beneath the surface of the liquid. The Kemp burner has a small chamber only large enough to maintain a flame; it must be ignited in the air and then immersed in the liquid.

No oil-burning equipment is in use, but experiments in these laboratories indicate that fuel oil may be used successfully in a submerged combustion burner.

(3) Advantages

The hot products of combustion leave the liquid at the same temperature as the liquid itself so that a Hammond heating system reports an efficiency of 95% of the gross heating value of the gas. This relationship has been calculated for a burner using methane as the fuel gas.[2]

As the gaseous products of combustion leave in thermal equilibrium with the liquid, they are

[1] (*a*) K. A. Kobe, "Submerged Combustion Attacks Difficult Heating and Evaporating Problems," *Chem. Met. Eng.*, **41**, 300–301 (1934).
(*b*) K. A. Kobe and C. W. Hauge, "Commercial Burners for Underwater Fires," *Power*, **77** [8] 402–403 (1933); *Ceram. Abs.*, **13** [1] 21 (1934).
(*c*) K. A. Kobe and C. W. Hauge, "Submerged Combustion Meets Many Industrial Heating Needs," *Power*, **77**, 460–61 (1933).

[2] K. A. Kobe, C. W. Hauge, and C. J. Carlson, "Evaporation by Submerged Combustion: III, Sodium Sulfate Decahydrate," *Ind. Eng. Chem.*, **28**, 589–93 (1936).

saturated with water-vapor. The temperature of the liquid becomes that at which the vapor pressure of the liquid plus the partial pressure of the gases equals the external pressure. When evaporating at atmospheric pressure, the temperature of the liquid becomes about 90°C, which is the boiling point. Thus submerged combustion evaporation is equivalent to evaporation under a slightly reduced pressure.

Heat transfer from the hot gases to liquid is extremely rapid. The gases are forced out into the liquid as small bubbles. When one cubic foot of gas is broken up into bubbles one thousandth of an inch in diameter, the surface becomes 72,000 square feet. Thus a burner need be submerged but a short distance so that the gases come to thermal equilibrium with the liquid.

The rise of the gas bubbles through the liquid produces vigorous agitation so that even very viscous liquids may be evaporated. Sulfite waste liquor was concentrated to 63% solids,[3] at which concentration it is a solid at room temperature. The Hammond system places the burner in a small circulation chamber so that the hot gases released from the burner act as an air lift to circulate liquid.

Corrosion is easily controlled as the burner is the only object at a temperature above that of the liquid. The burner may be constructed of a resistant metal; because the container wall is not used for heat transfer, low-cost metal or ceramic material may be used.

III. Dewatering Clay Suspensions

The common method is to filter-press the suspension, which gives a cake containing about 30% water. This is dried by hot air to 5% water and then pulverized. The highly colloidal nature of many transported kaolins makes filtration a lengthy operation. Wilson, Page and Cartwright[4] investigated the spray evaporation of such clay suspensions and found it to be satisfactory. Electrical methods have not yet come into use in this country.[5]

[3] K. A. Kobe, F. H. Conrad, and E. W. Jackson, "Evaporation by Submerged Combustion: I, Experimental Equipment; II, Sulfite Waste Liquor," *Ind. Chem. Eng.*, **25**, 984–89 (1933).

[4] Hewitt Wilson, G. A. Page, and V. S. Cartwright, "Dewatering Clay Suspensions by Spray Evaporation," *U. S. Bur. Mines Rept. Invest.*, No. 3248, 42 pp. (1935); *Ceram. Abs.*, **14** [4] 103 (1935); **15** [8] 252 (1936).

[5] W. A. Koehler, Principles and Applications of Electrochemistry: Vol. II, Applications, p. 507. John Wiley & Sons, Inc., New York, 1935. 545 pp.

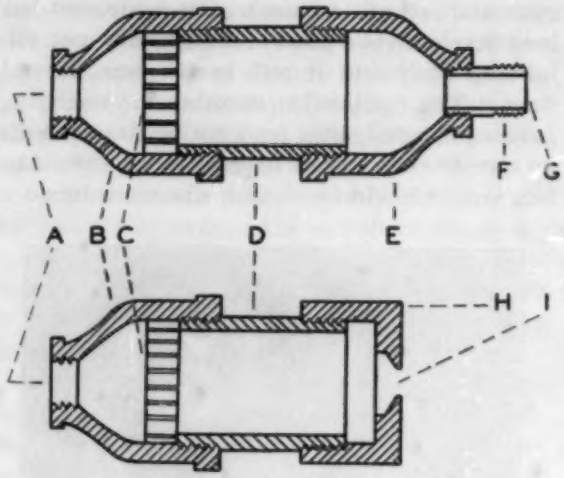

FIG. 2.—Two types of burners used.

IV. The Investigation

(1) Purpose

The advantageous features of submerged combustion have led to this study of its application to dewatering highly colloidal kaolins. Operating conditions, efficiencies, and the nature of the product have been investigated.

(2) Equipment Used

The evaporator was that used in the evaporation of sulfite waste liquor.[3] The evaporator, scales, and burner are shown in Fig. 1. The burners used were those employed in the evaporation of scale-forming salts[6] shown in Fig. 2. City gas and air were compressed in rotary compressors, passed through the mixing chamber to give a homogeneous mixture which was brought to the burner through a heavy hose. The burners (Fig. 2) were constructed from standard pipe fittings so the type of orifice through which the products of combustion issued could be readily varied. *B* is a reducer 1 to $^1/_4$ inch in size, *D*, a 1-inch nipple $1^1/_4$ inches long, and *H*, a 1-inch cap. *A* is connected to the gas-air supply from the mixing chamber through a $^1/_8$-inch pipe to give a high velocity to the gas mixture, thus preventing the flame from flashing back through the pipe. *C* is a screen, metal, or refractory grid, separating the flame zone in *D* from the gas-air zone in *B*. To *D* may be connected a cap, *H*, drilled to give

[6] K. A. Kobe and R. P. Graham, "Evaporation by Submerged Combustion: IV, Potassium Chloride from Sylvinite: V, Sodium Carbonate Decahydrate," *Ind. Eng. Chem.*, **28**, 593–94 (1936); (see also footnote 2).

any type orifice, as *I*, or a reducer, *E*, and nipple *F*, will give a short tube orifice, *G*.

(3) Evaporation Runs

The initial runs were made with water to secure data with which could be compared the runs using clay suspensions. The evaporator was placed on the scales, 60 pounds of water were added, and the burner was lighted in the air and immersed in the water. When the boiling point was reached and the steady state attained, data were taken at 15-minute intervals. The gas-air ratio used in the burner was controlled by an Orsat analysis of the flue gases. The water evaporated was determined by weighing at intervals. Runs were approximately three hours in duration. The average data and calculated results for a run on water are given in Table I, run (1). From these data were calculated the thermal and evaporation efficiencies by the method previously given in detail.[3]

A buff-firing clay from Lincoln, California, was dispersed in water to give a suspension containing approximately 7% clay. The sand and mica were allowed to settle out, the solids content was determined, and the slip was then placed in the evaporator. The slip was concentrated to 26% solids; data and results are given in run (2). It was not possible to carry the evaporation further because the liquid level had become too low in the body of the evaporator. To secure a larger volume of concentrated clay slip, two more runs were made in the same manner so that all the material used had undergone the same treatment.

The combined products of the three runs were placed in the evaporator and concentrated to 55% solids. Data and results are given in run (3). No difficulties were encountered until a concentration of about 45% solids was reached. Below this concentration, the liquid was fluid enough that the gases provided excellent agitation, and the burner remained free from any accumulation

TABLE I

DATA AND CALCULATED RESULTS FOR SUBMERGED COMBUSTION EVAPORATION

		Run No.			
		(1)	(2)	(3)	(4)
Material used		Water	Lincoln, Calif., clay slip		
Time of run (min.)		180	300	120	150
Gas used (cu. ft.)		76	138	57.5	75.5
Room temp. (°C)		26	22	23	23
Skin temp. of evaporator (°C)		32	25	25	23
Temp. H_2O in evaporator (°C)		87.7	87.8	86.5	88.8
Temp. of vapor (°C)		87.7	87.8	89.7	88.8
Weight of charge (lb.)		79.5	78	54	55
Exit-gas analysis	CO_2	10.5	10.5	12.8	12.3
	CO	0.0	0.0	0.0	0.0
	O_2	5.5	5.6	2.8	2.9
	N_2	84.0	83.9	84.4	84.8
Fuel-gas analysis	CO_2	4.4			
	C_3H_6	6.5			
	O_2	0.6			
	CO	16.8			
	H_2	34.2			
	CH_4	17.6			
	C_2H_6	1.9			
	N_2	18.0			
Fuel gas (B.t.u./cu. ft.)		500.0			
Ratio air to gas		6.08	6.07	4.97	5.2
Excess air (%)		33.9	34.5	14.1	15.3
H_2O evaporated	Weighed (lb.)	35.5	63.2	26.7	33.2
	Calculated (lb.)	34.7	63.7	27.6	33.2
Heat input	Heating value of gas	36,000	66,300	27,600	36,100
	Sensible heat of gas and air above 60°F	174	198	78	94
Total heat input (B.t.u.)		36,174	66,498	27,678	36,194
Heat output	Heat of vaporization of H_2O evaporated	31,400	55,500	23,500	28,500
	Heat of vaporization of H_2O from combustion	3,160	5,860	2,420	3,180
	Sensible heat in gases above 60°F	1,033	1,895	679	891
	Superheat of H_2O vapor	0	0	80	0
	Thermal recovery (B.t.u.)	35,593	63,255	26,679	32,571
	Radiation and unaccounted losses	581	3,243	999	3,623
Total heat output (B.t.u.)		36,174	66,498	27,678	36,194
Thermal efficiency (%)		98.3	95.2	96.5	90.1
Evaporation efficiency (%)		86.9	83.5	84.8	78.8

of solids upon it. Above 45% solids, it was necessary to move the position of the burner continually in the slip to prevent local overheating around the burner. As the viscosity increased, particles of clay clung to the burner and were vitrified by the high temperature of the burner. By continually changing the position of the burner, the growth of material around the burner was retarded, but at the end of the run a cone formation about 3 inches long was clinging solidly to the burner tip. In appearance it was similar to those of sodium sulfate previously described.[2]

Another run was made concentrating a slip from 29 to 66.7% solids. Data and results are given in run (4). The same difficulty occurred here as in run (3). The clay adhered to the burner tip as a cone was partially vitrified and was continually broken so that small hard particles were dispersed in the concentrated clay.

A white-firing clay was concentrated from 25% to about 65% solids, using an open evaporator so that operating data were not taken. The concentrated product was used for the ceramic tests.

(4) Examination of the Product

Similar tests were made on the original and evaporated clay to determine if this type of dehydration had altered any of the physical properties of the clay. Test bars, 1 by 1 by 8 inches, were made, dried to constant weight, and fired for 6 hours at 1800°F. Small bars, 30 by 30 by 45 millimeters, were dried and fired. The wet, dry, and fired volumes were determined in a mercury volumeter. After firing, the test pieces were compared as to color and texture; their transverse strengths were then determined.

V. Discussion of Results

The thermal and evaporation efficiencies are in good agreement with those previously determined for water and sulfite waste liquor.[3] The runs for water show the highest efficiencies. With the concentrated slips, it was difficult to have enough of the slip at the end of the run so that the burner could be submerged sufficiently to give complete thermal equilibrium. Furthermore, near the end of the runs some of the heat was used to cause partial vitrification of the clay adhering to the burner.

No difficulty of operation was encountered until the concentration had reached approximately 45% solids. Above this, the process had to be watched constantly to prevent local overheating as the viscosity of the slip had become too great for the gas bubbles to give sufficient agitation. The formation of hard, partially vitrified particles could not be prevented at these higher concentrations.

The ceramic tests made on the original clays and evaporated clays from which the hardened particles had been removed indicate that none of the original properties had been changed. The general plasticity and the drying and firing properties were the same.

VI. Summary

(1) Clay slips have been concentrated by means of submerged combustion up to 67% solids with thermal efficiencies up to 96%.

(2) The properties of the clay have not been altered by this evaporation process.

(3) The formation of hard particles at concentrations above 45% solids can not be prevented because the very high viscosity prevents agitation.

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CERAMIC ABSTRACTS

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October, 1937

16—10

Abrasives

Beilby layer. G. I. Finch. *Sci. Progress*, **31** [124] 609–25 (1937).—In 1901, George Beilby began the modern study of the effects produced when solid surfaces are ground, polished, or etched. The conception of the polish layer as being the result of a flowing of the material, whereby the surface becomes coated with an amorphous layer, is due to Beilby, and this is the layer named after him. G. P. Thomson (1930) put X-rays to use in studying the structure of polish. Finch (1934) found that the polish layer has the remarkable property, not possessed by a crystal surface, of being able to dissolve foreign crystals at room temperature. Bowden and Ridler (1936) measured thermoelectrically the temperature of formation of the Beilby layer on a metal surface while it was being burnished; they found that the temperature quickly rose to the melting point of the metal and was independent of any increase in the vigor of polishing. Hopkins and Lees (1935) found the thickness of the Beilby layer on hand-polished gold and copper surfaces to be 30Å or 15 to 30 atoms deep. The paper is illustrated with electron diffraction patterns of silicon carbide, spinel, sapphire, etc. See *Ceram. Abs.*, **14** [10] 237 (1935). H.H.S.

Control of abrasive dust: I. Fred B. Jacobs. *Mill & Factory*, **19**, 45–48 (July, 1936); *Metals & Alloys*, **7** [11] MA537 (1936).—J. discusses grinding methods with particular reference to the need for and existence of dust control. In practically all industries where metals are ground and polished, steps have been taken to eliminate silicosis hazards by installing large central dust-collecting systems or small portable dust exhausters for nonstationary work. Wet sandblasting is said to eliminate completely the dust hazard. Although the inhalation of silica dust is definitely dangerous, the inhalation of emery, silicon carbide, or alumina does not seem to result in injury. The need for control of dust appears to be greatest in gray Fe, malleable Fe, steel, and nonferrous foundries where the castings are ground dry to remove imperfections. Several grinding operations with and without dust removal equipment are illustrated. **II.** *Mill & Factory* **19**, 50–52, 120 (Aug., 1936); *Metals & Alloys*, **8** [2] MA95 (1937).—The dust hazard attendant on polishing operations is discussed. In dry polishing operations, such as roughing and dry finishing, the dust consists of metal particles; in oil finishing, because of the application of grease or emery cake, dust particles are not so numerous. The dust from buffing operations is almost entirely lint from the wheel and is less with motor-driven polishing and buffing lathes than with belt-driven. Hood and blower installations for several types of polishing and buffing lathes are described and illustrated. **III.** *Mill & Factory*, **19**, 56–59, 160 (Sept., 1936); *Metals & Alloys*, **8** [2] MA95 (1937).—An adequate system for the collection and disposal of abrasive dust is composed of four major components: the hoods over the grinding, polishing, or buffing wheels; the system of main and branch pipes; the fan for creating the air pressure in the system; and the collector that separates the dust from the air and deposits it in a bin for the purpose. Hoods of various designs are described and illustrated, and the method of determining the required fan capacity is outlined. The legal aspect of dust removal, with especial reference to variations in state laws or regulations, is discussed.

Finishing aluminum hollow ware. Anon. *Steel*, **99**, 32–35 (Dec. 28, 1936); *Metals & Alloys*, **8** [5] MA289

(1937).—A description is given of some of the more important operations and equipment used in the grinding, machining, and polishing of cast Al ware at the plant of Bremer Aluminum Co., New Washington, Ohio.

Manufacture of emery paper. A. BECKER. *Schleif- & Poliertech.*, **14** [2] 27–34 (1937).—B. gives a step-by-step description. 12 illustrations. F.E.V.

Polishing and buffing nonferrous metals. R. S. LEATHER. *Abrasive & Cleaning Methods*, **1** [2] 17–21 (1936); abstracted in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 92, p. 22 (1936).—L. gives a series of tabulated digests of knowledge, including abrasives commonly used on various metals; polishing and buffing zinc base die-castings; finishing operations for Ni, Ni plate, and Monel; and finishing operations for brass. See *Ceram. Abs.*, **16** [8] 229 (1937).

Preparation of corundum abrasive powders at the Moscow plant. A. M. NEMTINOV. *Gorno-Obogatitel. Zhur.*, No. 3, p. 13 (1937).—The plant handles Semiz-Bugu corundum grains of 0.7 to 1.4 mm. having the following average composition: Al_2O_3 91.58, Fe_2O_3 1.32, SiO_2 1.84, TiO_2 0.41, FeO 0.31, CaO 0.19, MgO 0.07, K_2O+Na_2O 0.42, and SO_3 1.48%. The corundum is ground to 0 to 75 μ and the soluble part is removed with HCl and hot water. The fraction 0 to 5 is decanted with cold water while the fraction 5 to 75 μ is further classified into fractions 5 to 7, 7 to 10, 10 to 14, 14 to 20, 20 to 28, and 28 to 75 μ. During 1936, the plant produced 750 tons. B.Z.K.

Process to determine the numerical efficiency of grinding powders. W. DAWIHL, O. FRITSCH, AND M. STOCKMAYER. *Schleif- & Poliertech.*, **14** [1] 1–3 (1937).—Diamond, hard metal, and glass samples were subjected to wear and tear tests by different grinding powders. The test process allows an accurate numerical comparison of the efficiency of abrasives for a given sample and also of the resistance of different samples for a given abrasive. The comparison of efficiency of different abrasives depends on worked material. American and German boron carbides used for loose-grain grinding are equally efficient. Illustrated. F.E.V.

Rail grinders—what progress in their development? ANON. *Railway Eng. & Maintenance*, **32**, 539–41 (Sept., 1936); *Metals & Alloys*, **8** [1] MA27 (1937).—Since the introduction of track grinders, constant redesign and development have been carried out. Track grinders may be classified as (*a*) rail-surface, (*b*) side-flow, and (*c*) cross grinders. Rail-surface grinders are further subdivided into those using revolving wheels and those of the reciprocating type.

REPORTS

Abrasive garnet in 1936. ANON. *U. S. Bur. Mines Mineral-Market Rept.*, MMS 551, 1 p. Free. An advance summary is given. R.A.H.

Abrasive materials industry in 1936. ANON. *U. S. Bur. Mines Mineral-Market Rept.*, MMS 552, 3 pp. Free. An advance summary for this industry is given. R.A.H.

PATENTS

Abrading machine. C. G. BROSTROM (United Shoe Machinery Corp.). U. S. 2,087,238, July 20, 1937 (Feb. 11, 1935). A machine for scouring channels and channel flaps formed in shoe soles is described.

Abrading wheel forming device. G. S. GOULD. U. S. 2,088,084, July 27, 1937 (July 22, 1935). A wheel for forming the surface of an abrading wheel has a circular concentric series of projecting abutments substantially radial on one side, the opposite side gradually thickening toward the base, and hard blades cemented to the radial surfaces of the abutments in radial position and at a wide circumferential distance apart, the blades having a central convex configuration and sides slanting outwardly therefrom.

Abrasive cutting machine. DARTREY LEWIS, W. L. WALSH, AND W. B. LASHAR, JR. (American Chain & Cable Co., Inc.). U. S. 20,466, Aug. 10, 1937 (Dec. 14, 1936); reissue of orginal 2,031,052 (*Ceram. Abs.*, **15** [5] 140 (1936)).

Abrasive device. C. W. Foss (Carborundum Co.). U. S. 2,087,318, July 20, 1937 (July 8, 1936). A flexible abrasive article comprises a composite backing consisting of a hydrated cellulose sheet, a fabric sheet adhesively attached to one face of the cellulose sheet, and a heat-hardened resin filling the interstices of the fabric sheet in a quantity sufficient to provide the fabric component of the backing with a relatively rigid brittle characteristic and a layer of abrasive particles adhesively attached to the face of the fabric.

Abrasive materials. I. G. FARBENIND. A.-G. (Georg Kränzlein and Richard K. Müller, inventors). Ger. 638,064, Nov. 10, 1936; Cl. 39*b*. 22; *Chem. Abs.*, **31**, 1175 (1937).—As binders for securing abrasive granules to a paper or fabric support, use is made of mixed esters obtained by esterifying a polyhydric alcohol partly with an aliphatic acid of at least 10 C atoms and partly with a polycarboxylic acid or a synthetic resin acid derived from a phenolaldehyde resin. A typical binder is prepared by esterifying glycerol with linoleic and phthalic acids. Other examples are given. The esters may be used in solution in an organic solvent or in aqueous suspension and are finally hardened by heat, with or without pressure. Since the esters have waterproofing properties, they may be applied to both sides of the support, the abrasive being then applied either to one side or to both sides.

Abrasive tool. O. S. BUCKNER. U. S. 2,090,104, Aug. 17, 1937 (Sept. 2, 1936). An abrasive wheel comprises a body of abrasive grains united by a heat-vulcanized bond of shellac, in which sulfur and an activator have been intimately mixed.

Blade sharpener and grinder. I. C. GELLMAN. U. S. 2,087,769, July 20, 1937 (Aug. 14, 1935).

Buffing wheel. S. W. LIPPITT. U. S. 2,087,693, July 20, 1937 (Feb. 3, 1936).

Control mechanism for grinding machines. PETER PLANTINGA (Greenfield Tap & Die Corp.). U. S. 2,089,002, Aug. 3, 1937 (May 20, 1935).

Electrical controlling device for grinding and abrading machines. C. E. EVERY-CLAYTON (Wotan- und Zimmermannwerke Akt.-Ges.). Brit. 469,009, July 28, 1937 (Dec. 11, 1935).

Garnet abrasive. R. H. RIZOR (Mid-West Abrasive Co.). Can. 367,472, July 20, 1937 (Oct. 5, 1936). G.M.H.

Garnet abrasive manufacture. R. H. RIZOR (Mid-West

Abrasive Co.). Can. 367,471, July 20, 1937 (Feb. 8, 1936). G.M.H.

Grinding or abrading wheels. NORTON GRINDING WHEEL CO., LTD. Brit. 468,097, July 14, 1937 (June 13, 1935).

Grinding hard sintered carbide compositions. P. H. WALKER AND A. H. PREY (Carborundum Co.). U. S. 2,090,274, Aug. 17, 1937 (June 4, 1934). A bonded abrasive article for abrading hard metal carbide compositions comprises abrasive material consisting of silicon carbide grains including at least 50% of clear green crystals, the abrasive article being relatively soft and at least 40% porous.

Grinding machine. C. G. FLYGARE (Norton Co.). U. S. 2,088,549, July 27, 1937(Oct. 19, 1935).

Grinding machine steady rest. C. G. FLYGARE (Norton Co.). U. S. 2,088,550, July 27, 1937(July 21, 1936).

Grinding wheel. JOHN GREENWOOD (Lancaster Machine Knife Works, Inc.). U. S. 2,089,847, Aug. 10, 1937 (June 20, 1936). A grinding wheel having a rotary support provided with a substantially cylindrical surface, a plurality of grinding segments having substantially flat parallel sides and arranged in rows extending circumferentially of the cylindrical surface, the segments of each row being spaced apart at their ends to form open pockets between adjacent segments and being arranged in staggered and overlapping relation to and in contact with adjacent segments of the other row, and means for securing the segments to the support and arranged in the inner ends of the pockets, the outer portions of the pockets being open.

Grinding wheel. K. F. WHITCOMB AND H. W. WAGNER (Norton Co.). Can. 367,157, July 6, 1937 (July 19, 1934). G.M.H.

Internal grinder. H. E. BALSIGER, E. P. WINE, AND DANIEL GURNEY (Landis Tool Co.). U. S. 2,088,682, Aug. 3, 1937 (Aug. 5, 1933).

Lapping machine. H. S. INDGE (Norton Co.). U. S. 2,087,874, July 20, 1937 (Feb. 6, 1935).

Machines for lapping or polishing machine parts, etc., and methods of using such machines. JUNKERS FLUGZEUG- UND MOTORENWERKE AKT.-GES. Brit. 468,923, July 28, 1937(Dec. 7, 1935).

Machines for relief-grinding hobs and like tools. MONARCH TOOL CO., LTD., AND H. WILSON. Brit. 468,404, July 14, 1937(March 21, 1936).

Manufacture of abrasive articles. CARBORUNDUM CO. Brit. 469,400, Aug. 5, 1937 (Feb. 9, 1935).

Manufacture of abrasive coated webs. CARBORUNDUM CO. Brit. 468,216, July 14, 1937 (June 11, 1935).

Manufacture of tools for truing grinding wheels. A. H. LLOYD AND HARRY BOOTH. U. S. 2,088,379, July 27, 1937(May 15, 1936).

Method for producing abrading rolls for use on abrading or polishing machines. E. E. PRICE (G. H. Tennant Co.). U. S. 2,089,707, Aug. 10, 1937 (July 1, 1935).

Profiling and dressing grinding wheels. H. LINDNER. Brit. 468,874, July 28, 1937 (Dec. 30, 1935).

Segmental surface-grinding cylinders and cup wheels. MITCHELL'S EMERY WHEEL CO., LTD., T. E. PRENTICE, AND J. H. FLETCHER. Brit. 468,228, July 14, 1937(Jan. 1, 1936).

Surface-coated abrasive material. T. M. RICHMOND (Modern Engineers, Inc.). U. S. 2,089,426, Aug. 10, 1937 (May 9, 1935). In an article in the nature of sandpaper, etc., an adhesive comprises asbestos cement, zinc oxide, sodium silicate, and water.

Surface-grinding machines. K. JUNG (trading as K. Jung Maschinenfabrik). Brit. 468,867, July 28, 1937 (July 19, 1935).

Art and Archeology

Archeological outlines in prehistoric Persia. J. JOHNSON. *Sci. Amer.*, **156**, 308–10 (1937).—Excavation at Tepe Hissar in the bottom layer found pottery made on a wheel and painted in geometric designs, hovels of mud and straw, and a few copper ornaments. There is a gradual transition to the second layer, which is characterized by a burnished gray wheel-made pottery, better houses, more jewelry, and more elaborately worked metal. The third layer is also characterized by gray pottery, but the use of the potter's wheel has been abandoned. Here also is a wealth of metal objects and alabaster furniture. The first layer dates from about B.C. 3800, and the place was deserted soon after B.C. 2000. It may be possible to correlate the second layer with the first invasion of Indo-Europeans from northeast of the Caspian Sea into Persia, which took place about B.C. 3500 to 3000. W.D.F.

Artist in the glass industry. W. WAGENFELD. *Oesterr. Glaserztg.*, **2**, 3–13 (1937). J.F.H.

Ceramic discussions. RAOUL DE BLOTTEFIÈRE. *Céram., Verrerie, Email.*, **4** [8] 305–12 (1936).—The artistic renaissance in Italy was in the beginning a return to the artistic principles and realism of the ancient civilizations. Foremost among ceramists of that period is the name of Luca della Robbia (the elder). He was not the inventor of enameling with tin; that was an ancient importation from the orient. The characteristics of his school are as follows: paste composed of figuline clay, calcareous marl, and fine sand; biscuit firing of stamped clay; enameling of the biscuit with a mixture of lead-tin, white sand, common salt, and soda, which gives an opaque ground; firing this enamel; decorating with vitrifiable colors; and coating with a transparent enamel. B. lists the best known Italian ceramic factories of the Renaissance; each factory had its personal character regarding the execution of pieces, but all had the same tendency to overdo the details of ornamentation, a characteristic of the epoch but also an essentially Italian characteristic. Among French Renaissance masters, Bernard Palissy (*Ceram. Abs.*, **16** [9] 266 (1937)) is considered the leader of the French school. After 15 years of work, deceptions, broken hopes, and half successes, during which he conceived the idea of using a glass furnace for firing his enamel, he finally emerged a master craftsman. Half the decorators of ware in France at this time were Italians and their influence was greatly felt. Abaquesne is another great name of that period of French ceramics. See *ibid.*, p. 265. M.V.C.

Cold and leadless glazes. A. N. VARSHAVSKIĬ AND R. L. RYZHIK. *Stroitel. Materialy*, No. 12, pp. 25–28

(1936).—A solution of bakelite resin in alcohol can be used; ware covered with this glaze with appropriate dye has the appearance of ordinary glazed ware. Three different frits consisting of feldspar, sand, marble, and soda ash (in one case with chalk also) were prepared. Satisfactory results were obtained with all three. P.B. & E.S.

Faience of Nimes of the 16th Century. DEHLINGER. *Céram., Verrerie, Email.*, **4** [8] 329–39 (1936).—The faience of Nimes was originally inspired by Italian faience produced by the factories of Faenza during the period between 1540 and 1560 although they did not show that perfection which characterizes the production of the Faenza factories about 1550. Their defects were compensated by other qualities, *i.e.*, originality and charm. At Nimes a faience factory was founded by a Frenchman, Antoine Sigalon; his faience was decorated in the Italian style but was influenced by French taste. D. gives a résumé of what is known of the faience manufacture of this period; although it was rather short, it produced pieces rivalling those of the Italian Renaissance. A description is given of pieces of Nimes ware in public and private collections. M.V.C.

Lodi ceramics. ANON. *Ind. Vetro & Ceram.*, **10** [2] 32–33 (1937).—Between Adda and Po there is a large deposit of alluvial, clayey material. Very little of the Roman unglazed terra cotta has reached us. From the 12th to the 19th Century, the production was important, especially in majolica. F.E.V.

Plastic art in Australia. ANON. *Clay Prod. Jour. Australia*, **4** [9] 15 (1937).—The work of Loma Lautour and Deetje Andriesse of Sydney is described. H.H.S.

Principles of colorimetry and practical color measurement. J. W. PERRY. *Eidgenöss. Materialprüfungsanstalt E. T. H. Zürich, Ber.*, No. 38, *Diskussionsber.*, No. 15, pp. 49–56 (1928); *Chem. Abs.*, **31**, 298 (1937).—The principles of trichromatic colorimetry or that in which three primary colors are used as a basis of color comparison are discussed. The apparatus of Guild (*Ceram. Abs.*, **5** [8] 240 (1926)) is regarded as particularly satisfactory. Data obtained with this instrument are interpreted in terms of the three primary colors.

Purpose and form. W. WAGENFELD. *Oesterr. Glaserztg.*, **2**, 3 (1937). J.F.H.

Sardinian ceramics. L. ARIMATTEI. *Ind. Vetro & Ceram.*, **10** [3] 47–48 (1937).—A. gives a short description of Phoenician, Carthaginian, and Roman ceramic products found in Sardinia. The artistic production is negligible although raw materials are available. F.E.V.

Site of Ares shrine found. ANON. *N. Y. Times*, Aug. 8, 1937.—The exact location of the Temple of Ares has been found in the market place of ancient Athens by excavations of the American School of Classical Studies. Investigations of pits and shallow wells revealed a large quantity of sherds and many complete vases dating from the late Neolithic (B.C. 3000), early Helladic (B.C. 2500), and middle Helladic (B.C. 1800) periods. The late Neolithic vases are of excellent material. One, of red ware highly burnished on the exterior, has holes in the side handles and the base, apparently provided for the passage of withes to hold the cover in place. Excellent specimens from the middle Helladic period were recovered, with coarse ware pots of the early Helladic period. A middle Helladic mat-painted jug with a bridged spout and horizontal side handles reflects in shape the "island" influence of the flourishing Cretan civilization. Below the rim it is painted with a narrow band of crosses surmounting a broader band with a running spiral design. Vases for a variety of purposes and ranging in time from B.C. 1000 to the Roman age were excavated. Sculpture of the earlier periods is quite rare, since Sulla destroyed or carried away to Rome most of the better pieces in B.C. 86. One of the best of the few earlier statues recovered is a handsome head of a woman found in the same well as a vase of the Roman age. The style is that of the late Praxitelean period, while the features recall the common type of portrayal of the goddess Aphrodite. Miscellaneous items include terra cotta dogs and horses, the toys of ancient Greek children. M.V.C.

PATENTS

Coloring pottery. M. PERKIEWICZ. Ger. 635,521, Sept. 21, 1936; Cl. 80*b*. 12.11; *Chem. Abs.*, **31**, 829 (1937).— A colored surface is produced by coating pottery with pigment mixed with resin, water, and an organic liquid and firing. The resin is dissolved in an organic solvent whose vapor tension is greater than that of water. The pigment is mixed with clay or other ceramic products. Instead of resin, resinates of Fe, Co, Mg, or Ba may be used. Glaze powder may be mixed with the pigment instead of clay.

Designs for:

Bottle. R. A. MILLS (Maison Joubert, Inc.). U. S. 105,669, Aug. 17, 1937 (June 22, 1937).

Closure. J. M. WHEATON (Owens-Illinois Glass Co.). U. S. 105,723, Aug. 17, 1937 (Dec. 29, 1936).

Condiment shaker. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 105,667, Aug. 17, 1937 (June 9, 1937).

Cream pitcher. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 105,395, July 27, 1937 (June 9, 1937).

Decanter. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 105,393, July 27, 1937 (June 9, 1937).

Double boiler. E. B. STERN (McKee Glass Co.). U. S. 105,718, Aug. 17, 1937 (March 19, 1937).

Glass refrigerator dish, etc. A. H. NICHOLSON. U. S. 105,400, July 27, 1937 (June 16, 1937).

Jar. O. C. NOBLE (Tygart Valley Glass Co.). U. S. 105,671, Aug. 17, 1937 (July 2, 1937).

Plate. YUKIO BUMA (Morimura Bros., Inc.). U. S. 105,689, Aug. 17, 1937 (Dec. 10, 1936); refiled for abandoned application Serial No. D-59,039, Oct. 16, 1935. U. S. 105,690, Aug. 17, 1937 (Dec. 10, 1936); refiled for abandoned application Serial No. D-59,142, Oct. 21, 1935.

Sugar bowl. W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 105,394, July 27, 1937 (June 9, 1937).

Tumbler. J. B. BOEHM (Morgantown Glass Works). U. S. 105,430, July 27, 1937 (Feb. 23, 1937). U. S. 105,567, Aug. 10, 1937 (Feb. 23, 1937).

Cements

Anhydrite-slag cement. P. P. BUDNIKOV. *Concrete* [Cement Mill Ed.], **43** [11] 35 (1935).—The addition of 10% dry granulated basic blast-furnace slag to dead-burned anhydrite gives the highest compressive strength, having a value of about 1200 and 1600 lb./ sq. in. at 7 and 28 days. It differs from other anhydrite cements in that it has hydraulic properties. W.D.F.

Carbonation of unhydrated Portland cement. ANON. *Ind. Chemist*, **12** [139] 381 (1936).—Exposure of three normal and one rapid hardening Portland cements to moist air and carbon dioxide shows that, while moist air free from carbon dioxide has little effect and dry carbon dioxide none, mixtures of the two decompose certain constituents of the cement and have the effect of rapidly increasing the loss on ignition and the carbonate content with increasing time of exposure. H.E.S.

Causes of unsoundness of cement. A. J. BLANK. *Concrete* [Cement Mill Ed.], **43** [6] 38–40 (1935).—B. reviews the literature. Frequently, unsoundness is said to result from free lime or free magnesia and occasionally from alkalis, sulfoaluminates, and excess dicalcium silicate. W.D.F.

Compound content of Portland cement. F. M. LEA. *Concrete* [Cement Mill Ed.], **45**, 154 (1937).—Bogue's method of calculating cement compound composition depends on equilibrium being reached. A paper by Lea and Parker questioned this and suggested that some glass was formed. A misunderstanding has arisen in that some think the authors said the liquid present formed only glass. This is incorrect. The liquid phase present may not have time to run through the complex reactions leading to equilibrium, due to the quick cooling, but may crystallize independently of the solid phase or form a glass or a mixure of both. W.D.F.

Development of firing with solid, liquid, and pulverized fuels. H. JORDAN. *Zement*, **26** [22] 357–61; [23] 375–78 (1937).—J. reviews recent German patents and gives a description and analysis. Illustrated. F.E.V.

How rotary cement kilns are insulated. J. C. CRAWFORD, JR. *Concrete* [Cement Mill Ed.], **43** [10] 35–38 (1935).—Detailed drawings of an installation are given. W.D.F.

Influence of granulometric composition and of different salts on the heat of hardening and mechanical properties of Portland cement. P. P. BUDNIKOV AND L. G. GULINOVA. *Zhur. Priklad. Khim.*, **9** [11] 1937–50 (1936). P.B. & E.S.

Natural and artificial pozzolanas: I. MANUEL DE LOS SANTOS. *Cemento* [Barcelona], Feb., 1935; translated in *Concrete* [Cement Mill Ed.], **43** [6] 42–43 (1935). W.D.F.

Research on the shrinkage of cement, mortar, and concrete. R. DUTRON. *Ciment*, **40** [1] 15–18 (1935).—Based on numerous results of researches made by him, D. gives this résumé. The shrinkage and swelling of mortar and concrete seem to depend on two main causes: (1) reactions of hydration of the constituents of the cement, which may lead to final compounds showing volumes entirely different from the initial volumes of the reacting substances; and (2) purely physical actions due to capillary forces of the interstices. E.ST.

What is pozzolana? I. M. PALMIERI. *Concrete* [Cement Mill Ed.], **43** [5] 42–45 (1935).—Pozzolana mortar was used in existing structures built at least 2000 years ago which are still in good condition. They are formed by the explosive ejection of molten lava and are highly porous, amorphous mixtures of free silica and alkaline silico-aluminate. They swell when immersed in lime water, forming calcium silicate or calcium silico-aluminate gel which progressively hardens with dehydration. All the lime can be leached out without disintegration or loss of strength. The chemical composition is of little use in identifying a pozzolana, and physical tests have to be made. **II, Tests of pozzolanic activity.** *Ibid.*, [7] 39–41.—Because of the great variability in the chemical and physical composition of pozzolanic materials they can be recognized only as follows: (*a*) reaction with lime, (*b*) to give a hydraulic cementitious substance, (*c*) with high chemical resistance, and (*d*) increasing physical resistance. Testing for soluble silica does not help, and neither does the absorption of lime from a solution, without ascertaining that the lime is forming a stable compound and a hydraulic cement. W.D.F.

PATENT

Cements for metallic and ceramic articles. ROBERT BOSCH A.-G. Ger. 635,111, Sept. 10, 1936; Cl. 80*b*. 12.06; *Chem. Abs.*, **31**, 232 (1937).—For uniting metal and (or) ceramic surfaces, use is made of cements comprising powdered Al_2O_3, preferably corundum, 95 to 99.8% and a fluosilicate, preferably MgSiF, 5 to 0.2%, brought to a suitable consistency with the aid of a concentrated water-glass solution. The use of the cements for fixing the middle electrodes of spark plugs is mentioned, and in this case a water-glass solution of 30°Bé is preferably used. More concentrated solutions may be used with articles not required to withstand high temperatures.

Enamel

Analysis of cast and pig irons. R. TAYLOR. *Ind. Chemist*, **12** [139] 372–74 (1936).—T. gives a few practical suggestions to make combustion estimations more useful and accurate and describes and illustrates the complete combustion apparatus for determining the amount of total carbon in pig and cast irons. H.E.S.

Defects in enameling. J. NAPPÉE. *Céram., Verrerie, Email.*, **4** [2] 55–58; [6] 231–34 (1936).—Defects in enameling are explained, and reference is made to N.'s book, Mechanical Working of Sheet Iron (*Ceram. Abs.*, **14** [6] 134 (1935)). See *ibid.*, [3] 64 (1935). M.V.C.

Effect of iron surface preparation upon enamel adherence. KARL KAUTZ. *Jour. Amer. Ceram. Soc.*, **20** [9] 288–95 (1937).

Electrically heated convection heat-treating furnaces for light metal sheets. H. DICKS. *Elektrowärme*, **7** [6] 117–22 (1937).—Furnaces with air movement are described and compared with salt bath furnaces. M.H.

Elements of costing with reference to vitreous enameling. J. W. G. PEDDER. *Sheet Metal Ind.*, **10** [116] 951–52, 957 (1936); **11** [117] 55–56 (1937).—Practical notes are given. A.P.S.

Enamelers of the 19th and 20th centuries. GASTON RICHET. *Céram., Verrerie, Email.*, **4** [9] 345–49 (1936).—In 1840 began a renaissance of the art of enameling in France. A number of goldsmiths conceived the idea of enriching their works with enamels. The movement was confined to private enterprise until the Exposition of 1844, after which, in response to popular demand, King Louis-Philippe ordered an atelier for enameling on metal to be opened at the Sèvres factory and Meyer-Heine was put in charge. The latter made small enameled plaques to be mounted on brooches and jewelry, which influenced later trends. Some time later, Ebelman at Sèvres decided to make these plaques in large dimensions, and though some of this work survives, R. contends that when an artist enameler works in large dimensions, he commits the fault of losing the precious quality of this admirable material. Alfred Meyer and Claudius Popelin, both artist painters and writers, achieved success with their work in enamels. See *Ceram. Abs.*, **16** [9] 268 (1937). M.V.C.

Enameling of steel. A. E. FRISTEDT. *Industritidning. Norden*, **63**, 67–68 (1935); *Chem. Abs.*, **31**, 3225 (1937).—A review is given.

Gas opacification of enamels. R. ALDINGER. *Keram. Rundschau*, **45** [2] 13–15 (1937).—The importance of gas bubbles for opacification was often emphasized in the technical literature. Since the patent of I. Kreidl (*Ceram. Abs.*, **15** [8] 232 (1936)), it was verified that gas always intervenes in the opacification of enamels. Experiments to obtain opacification by gas alone or mainly by gas are encouraging. F.E.V.

Low-temperature carbonization. DAVID BROWNLIE. *Engr. of India*, **5** [1] 15–18 (1937).—B. describes the "Berg," "Pintsch-Weber," and "Hinselmann" processes now being developed in Germany. See also *Ceram. Abs.*, **12** [7] 275 (1933). A.P.S.

Metal degreasing prior to vitreous enameling. N. R. HOOD. *Sheet Metal Ind.*, **11** [119] 301–302; [120] 383–85 (1937).—H. reviews the three processes in common use in the vitreous enameling industry for the degreasing of metal, *i.e.*, the mechanical process, the burning-off process, and the chemical process, the application of the first two being limited to special cases; methods using alkalis and solvents, however, have the widest application. The fundamental factors to be considered in an alkali detergent process, *e.g.*, the wetting and penetrative power of the solution, the emulsifying power of the cleaner, and strength of solution, are discussed. Fire risk involved in organic solvents, the latest development in metal cleaning, has been eliminated by the development of chlorinated hydrocarbons, which are noninflammable, the best known being trichlorethylene which has a vapor heavier than air. The fundamental principles and the essential features of plant design operating on trichlorethylene or other chlorinated solvents are outlined; the essential factors to prevent excessive solvent loss during operation are given. A.P.S.

Methods of enamel application. RICHARD ALDINGER. *Glashütte*, **67** [17] 273–76 (1937).—A. classifies enameling methods as follows: (1) hand application, (2) semi-mechanical, and (3) mechanical methods. M.V.C.

Practical wage-incentive plan for porcelain enamel plants. E. J. GOENS AND R. F. HURST. *Ceram. Ind.*, **27** [5] 332–33; [6] 436–42 (1936); **28** [1] 82–86; [2] 156–60; [3] 232–34 (1937).—In this series of articles complete details are given of an "individual" wage-incentive plan conceived and placed in operation in the porcelain enameling plant of Roberts & Mander Stove Co., with results of higher pay, lower costs, better work, and satisfied workmen. The methods of setting standards and incentives for various workmen on rated operations and tying in unrated employees to make all employees have actually double incentives are discussed in detail. Education of the employees so that they can determine just how much bonus they have earned by simple calculations involving their work-time records is explained. E.J.V.

Robot sprayer improves ware in enameling plant. ANON. *Ceram. Ind.*, **27** [4] 259 (1936).—Operating details are given. E.J.V.

PATENTS

Enamel. PFAUDLER-WERKE A.-G. Ger. 639,922, Dec. 16, 1936; Cl. 48*c*. 2.01; *Chem. Abs.*, **31**, 4076 (1937).—A heat-resisting frit for enamel consists of 30 to 40 quartz, 10 to 14 clay, 2 to 5 Ni_2O_3 or Co_2O_3 or both, and 5 to 10% Cr_2O_3. The frit is fused by heating to 900 to 1000°.

Enameling. WERNER SCHREIBER. Ger. 634,518, Aug. 29, 1936; Cl. 48*c*. 8; *Chem. Abs.*, **31**, 520 (1937).—The inner surfaces of sheet metal or plated ware are roughened and coated with enamel while the outer surfaces may be plated with Cr.

Enameling iron. PHILIPP EYER. Ger. 630,896, June 8, 1936; Cl. 48*c*. 2.02; *Chem. Abs.*, **31**, 233 (1937). Addition to 613,293 (*Ceram. Abs.*, **15** [8] 231 (1936)).—Zr antimonate, or a product obtained by heating ZrO_2 with Sb_2O_3, is used in the process of Ger. 613,293 in place of the whole or a part of the corresponding compounds of Zn. Ger. 634,958, Sept. 7, 1936; Cl. 48*c*. 2.02; *Chem. Abs.*, **31**, 830 (1937). Addition to 630,896.—Antimonates of alkaline earth or earth metals, or products obtained by heating Sb_2O_3 with oxides of alkaline earth or earth metals, are used in the process of Ger. 613,293 in place of the corresponding compounds of Zn or Zr.

Grate for enameling furnace. OTTO JUNKER G.M.B.H. Ger. 641,032, Jan. 19, 1937; Cl. 48*c*. 7; *Chem. Abs.*, **31**, 3230 (1937).

Removing enamel from metals. I. G. FARBENIND. A.-G. Ger. 641,031, Jan. 18, 1937; Cl. 48*c*. 4; *Chem. Abs.*, **31**, 3230 (1937).—Mixtures of HF and H_2SO_4 are used for removing enamel coatings from metals. Suitably, a bath containing HF 20 and H_2SO_4 20% is used at 20 to 30°.

Glass

All-glass constructions. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 29–31 (1937). J.F.H.

Constitution of glass. N. A. SHISHAKOV. *Sorena*, pp. 52–56 (1935); *Jour. Soc. Glass Tech.*, **21** [83] 3A (1937); see *Ceram. Abs.*, **15** [2] 58 (1936); **16** [3] 85 (1937).

Cutting glass and mirror panes. ANON. *Oesterr. Glaserztg.*, **2**, 13–14 (1937). J.F.H.

Dielectric losses in glasses. N. P. BOGORODITSKIĬ AND V. N. MALYSHEV. *Zhur. Tekh. Fiz.*, **5**, 612–19 (1935); *Chem. Abs.*, **31**, 14 (1937).—Data are given for tan δ for a large number of acyl-celluloses, artificial fibers, and resins, for various borate, phosphate, K, Na, Pb, Al, and Ba glasses, and for various minerals. In glasses tan δ is almost the same for both high and low frequencies and increases with temperature. The lower the ohmic resistance, the lower is the temperature at which tan δ begins to increase. Addition of oxides of alkali metals causes a rise of tan δ with temperature by increasing the conductivity.

Double-belt leer handling ware of two distinct types. JOHN KLUMPP, JR. *Ceram. Ind.*, **27** [4] 257–58 (1936).—To meet a specific production problem involving the annealing of two different types of glassware, a new and unique annealing leer with a double-belt conveyer, each belt moving independently of the other and making it possible to have two annealing curves simultaneously within the same leer, was placed in operation at the Elwood, Ind., plant of Macbeth-Evans Glass Co. Advantages found in this equipment are flexibility, lower investment cost than would be required for two single-belt leers, reduction in fuel costs since there are less radiation losses, lower maintenance cost, and some saving in labor. Complete construction details are given. E.J.V.

Effect of heat treatment on the thermal expansion of some silica alumina glasses. C. L. THOMPSON AND C. W. PARMELEE. *Jour. Amer. Ceram. Soc.*, **20** [9] 305–308 (1937).

Elastic and viscous properties of several soda-silica glasses in the annealing range of temperature. N. W. TAYLOR AND P. S. DEAR. *Jour. Amer. Ceram. Soc.*, **20** [9] 296–304 (1937).

Electron diffraction by transmission through thin silica glass films. LOUIS R. MAXWELL AND V. M. MOSLEY. Presented at meeting of Amer. Phys. Soc., Pittsburgh, Pa., Dec., 1934; abstracted in *Phys. Rev.*, **47**, 330–31 (1935).—Electron diffraction has been obtained by the transmission of electrons (25 to 38 kv.) through thin films of silica glass. The films were obtained from the glass after blowing out into a thin-walled bubble. Further reduction in the thickness of the film was made by treatment with HF acid. The interference pattern recorded on a photographic plate can be described as follows: (1) at small angles the electron scattering was strong in contrast to the known X-ray photographs which show small scattering in this region; (2) the prominent ring at $(1/\lambda)\cdot \sin \theta/2 = 0.12$ commonly observed by X-rays was present; (3) at $(1/\lambda)\cdot \sin \theta/2$ equal to about 0.20 a prominent halo was observed; (4) a strong diffuse ring appeared at $(1/\lambda)\cdot \sin \theta/2 = 0.40$. These results can be discussed from the standpoint of scattering from amorphous SiO_2 previously treated by Warren (*Ceram. Abs.*, **13** [11] 289 (1934)). Frequently sharp interference spots or partially completed circles characteristic of crystal formation were found in addition to the above pattern. The most prominent ones give Bragg spacings of 4.2Å (strong), 3.7Å (strong), and 2.52Å (weak). The origin of this pattern has not been definitely established and it is possible that it may arise from impurities. J.L.G.

Faults in manufacturing safety glass with a cellulose ester binder. T. PESCH. *Chem.-Ztg.*, **61**, 296–98 (1937); *Chem. Abs.*, **31**, 5119 (1937).—The paper is intended to supplement the textbook of H. G. Bodenbender, "Sicherheitsglas" (*Ceram. Abs.*, **12** [10–11] 369 (1933)). Failures of such glass result from impurities of the binding material caused by dust particles of various kinds, incomplete adhesion caused by nonhomogeneity of the binder, and various other causes mentioned in detail. P. recommends measures to avoid such failures based on his own and other research workers' experiences.

For the auto glazer. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 84 (1937).—Correct and incorrect methods of mounting in a metal frame are illustrated. J.F.H.

Formation of stones from refractories. ANON. *Sprechsaal*, **70** [9] 115 (1937).—The formation of stones in glass from the refractory materials of the tank is discussed. Illustrated. M.V.C.

Fused silica in heating processes: I, Furnaces and heated inclosures. W. L. PATRICK AND G. N. PEEL. *Ind. Chemist*, **12** [136] 221–26 (1936).—Fused silica is available in the transparent form and the translucent form. The compositions of both are about 99.8% SiO_2. The difference in their physical structures is due chiefly to the small gaseous inclusions which give the translucent form its opaque appearance. At temperatures above 1000°C, molecular rearrangement into the more symmetrical crystalline form tends to occur, and consequently a temperature of 1100°C is the upper practical limit. Compared with other structural materials, fused silica has a low thermal conductivity. It is an excellent electrical insulator at normal temperatures and still has high resistance at 1100°C. Chemically, it is unaffected by acids, except hydrofluoric acid and (at temperatures above 300°C) phosphoric acid, and by most gases and vapors. It is not resistant to alkalis, and certain basic salts and metallic oxides have specific effects, but at temperatures below 750°C, no reaction between oxides and fused silica is likely to occur. The application of fused silica as muffles and tubes in resistance furnaces, as a sleeve or former in induction furnaces, muffles in gas-fired furnaces, and as coal gas-air burners is described. Illustrated. See also *Ceram. Abs.*, **16** [6] 170 (1937); for Part II see this issue, p. 309. H.E.S.

Glass and concrete construction. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 86–89 (1937).—The method of construction of a small dome carrying round glass inserts is illustrated photographically. J.F.H.

Glass etching. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 75–78 (1937).—Etching formulas and techniques are given for carrying out various types of work. J.F.H.

Glass transparent in only one direction. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 78 (1937). J.F.H.

Glass in western Pennsylvania. ANON. *Amer. Glass*

Rev., **56** [40] 9 (1937).—A tabulation has been made from U. S. Bureau of the Census data of the productive activity of the flat glass, container glass, and glassware industries in eleven western Pa. counties biennially from 1929 to 1935. A.P.

Glasses containing iron oxide: X. K. FUWA. *Jour. Japan. Ceram. Assn.*, **44** [524] 542–46 (1936).—Lithium oxide-lime-silica glasses, in which increasing quantities of CaO are replaced by Fe_2O_3, are described. Glasses conforming to the oxide composition 72% SiO_2, (12 − *x*)% CaO, and 16% Li_2O, in which the quantity of *x* lies between the limits ranging from 0 to 12% of Fe_2O_3, have been melted, and their general characteristics (FeO content, actual oxide compositions by chemical analysis, and characteristic transmission curves) have been determined. The corroding action of the lithium oxide glass upon the fireclay pot, being far greater than that of the corresponding soda or potash glasses, has prevented experiments of factory scale melting, which have been dealt with in previous papers. F. has carried out this series of melting operations with a Globar electric furnace in the shortest possible time, *e.g.*, about 2 hr., each melt being 250 g. of glass. The results of the chemical analysis are given in a table. The table shows that the amount of alumina in this series of glasses is far more than that contained in the series of the other alkali oxide glasses and that the percentage ratio FeO/FeO + Fe_2O_3 of these glasses presents a somewhat different tendency from that of the corresponding series of soda or potash glasses, which is considered to be due to the small amounts of the melts and the agitation at one time in the course of melting to avoid the inhomogeneity of the glasses obtainable. In the determination of the transmission curves of the test samples, about 0.8 mm. in thickness, no remarkable characteristic differing from that of the soda or potash glasses has been observed. The glasses of this series presented, in general, a greenish color with increasing amount of iron oxide and a dark brownish color with a considerable amount of iron oxide. For Parts **V-IXb** see *Ceram. Abs.*, **16** [3] 86 (1937).

How ophthalmic glass is made. F. R. WOODCOCK. *Optician*, **91**, 253–55 (1936); *Jour. Soc. Glass Tech.*, **21**, [83] 22A (1937).—Glasses used in ophthalmic work are (1) ophthalmic crown, a glass of the approximate percentage composition SiO_2 70, CaO 11 to 13, Na_2O 14 to 16, with small amounts of K_2O_3, B_2O_3, Sb_2O_3, and As_2O_3; (2) flint, *i.e.*, lead glasses, PbO 45 to 65, Na_2O + K_2O 7 to 10, SiO_2 remainder; (3) barium or barium flint glasses containing 25 to 40% BaO; and (4) colored glasses. According to Bausch and Lomb practice for pot melting, the time for a complete melting is approximately 22 hr. as follows: fusion 7 to 8, refining 7 to 8, and cooling down to casting temperature 6 to 7 hr. Stirring is carried out at the end of the refining period until the glass stiffens. Short periods of stirring might also be given during the earlier stages of refining to assist in forming large bubbles. The glass is cast and rolled to $^1/_8$-in. sheets which are put through an annealing furnace, taking 8 hr. in the process. To eliminate iron, the grog used in pot manufacture is screened and magnetted before use.

Improving Poshan glass. TIEH-SEN HU AND JUI-LIN LO. *Nat. Shantung Univ., Dept. Chem. Lab., Research Repts.*, No. 5, pp. 50–76 (1936); *Chem. Abs.*, **31**, 1565 (1937).—From the experiments made by the authors, the glass manufactured in the Poshan district, Shantung Province, China, should be improved along the following lines: (1) the Na_2O content should be decreased, (2) the furnace should be rebuilt to get a higher temperature, and (3) the annealing furnace should be improved so that the temperature can reach 650° and its walls should be made thicker.

Institute for Glass Research in Koniggratz. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 71–74 (1937). J.F.H.

Molecular orientation in liquid crystals. F. P. DWYER. *Jour. Australian Chem. Inst.*, **4** [5] 163–64 (1937).—A lecture is reported in which the types of substances that form liquid crystals, their range of temperature, the making of liquid-crystal glasses, and the effect of magnetic and electric fields were discussed. Specimens of polarizing glass were shown in which the polarization is achieved by the parallel orientation of minute crystals of a cobalt hexamine periodate. In the discussion, R. K. Murphy suggested the term "reguline" to cover forms of matter which show no outward crystal face but give a crystalline X-ray picture. H.H.S.

Origin of the word "glass." G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 35 (1937). J.F.H.

Philippine bagasse ash as a raw material for glass-making. SALVADOR DEL MUNDO. *Philippine Jour. Sci.*, **60**, 125–35 (1936); *Chem. Abs.*, **31**, 1565 (1937).—The composition of Philippine sugar cane bagasse ash very closely resembles that of common bottle glass. The ash contains about 81.5% SiO_2, 6% (Al_2O_3 + Fe_2O_3), 5% (CaO + MgO + MnO), and 7% (Na_2O + K_2O). The average solubility of the ash in water is usually less than 0.4%. The mechanical composition of the ash makes it a more suitable raw material than sand, as it is loose and very friable, giving more homogeneous batches. Since the ash is a complex silicate formed at high temperature, there is less danger from devitrification of the glass made from it. In spite of the relatively high content of Al_2O_3, batches made from the ash were actually found to melt easily. No difficulty was experienced in refining glass made from the ash. Analytical and comparative data are given. 9 references.

Physical characteristics and properties of textile materials made from glass. J. H. THOMAS. *Jour. Amer. Ceram. Soc.*, **20** [9] 309–10 (1937).

Principles of recirculation in glass annealing leers. H. C. WELLER. *Amer. Glass Rev.*, **56** [21] 10 (1937).—To obtain temperature uniformity in glass articles during annealing, the greatest possible surface should be exposed to the heating and cooling elements. Rapid recirculation of gases around the ware aids in maintaining uniform temperature throughout any vertical cross-section, counteracts outside drafts, and overcomes the problems met with large and irregular shapes. A.P.

Round tanks for window- and bottle-glass production. THOMAS B. HART. *Ceram. Ind.*, **27** [4] 270–72 (1936).—H. describes furnaces which are round or ellipsoid in shape, in which uniform temperature control and uniform glass-melting are obtainable by proper arrangement of luminous flame firing ports. The bridge walls are arcuate or semiarcuate to cause all extraneous matter forming upon

the surface of the glass in the melting end to eddy automatically in opposite directions to where the skimmer working through side-wall openings can remove them. A projected throat delivers the molten glass to a more central portion of the refining end. All constructional details are described with the aid of drawings. E.J.V.

Standard samples for the glass industry. ANON. *Bull. Amer. Ceram. Soc.*, **16** [8] 349 (1937).

Wall coverings of glass, technique of assembly, examples, and future possibilities. G. SCHIEB. *Oesterr. Glaserztg.*, **2**, 42–56 (1937). J.F.H.

PATENTS

Annealing upwardly drawn sheet glass. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Ger. 635,193, Aug. 27, 1936 (March 14, 1934); N 36,455, VI/32*a*, Gp. 23_{01}; *Jour. Soc. Glass Tech.*, **21** [83] 50A (1937). Heating elements are disposed in the shaft between the pairs of rollers to control the annealing of the sheet.

Apparatus for:

Conveying glassware into a furnace. WALTER FORSTER. Ger. 634,629, Sept. 3, 1936; Cl. 32*a*. 34; *Chem. Abs.*, **31**, 517 (1937).

Distributing molten glass. W. T. BACKER, JR. (Aktiebolaget Surte-Liljedahl). Swed. 83,098, April 9, 1935; *Chem. Abs.*, **31**, 2766 (1937).

Forming the stems of glass vessels. JAKOB DICHTER. Ger. 632,757, July 13, 1936; Cl. 32*a*. 26; *Chem. Abs.*, **31**, 230 (1937).

Grinding edges of glass plates. L. J.-B. FORBES (Triplex (Northern), Ltd.). U. S. 2,088,737, Aug. 3, 1937 (April 3, 1936).

Hardening glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Ger. 634,628, Aug. 31, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **31**, 517 (1937).

Hardening glass plates. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Ger. 636,893, Oct. 15, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **31**, 3227 (1937).

Making glass sheets. N. V. HOLLANDSCHE MIJ. VOOR DE VERVAARDIGING VAN GLAS. Fr. 801,881, Aug. 20, 1936; *Chem. Abs.*, **31**, 1569 (1937).

Making glass threads. COMPTOIR DES TEXTILES ARTIFICIELS (SOC. ANON.). Fr. 806,037, Dec. 5, 1936; *Chem. Abs.*, **31**, 4467 (1937).

Making hollow glass articles. HARTFORD-EMPIRE CO. Fr. 807,168, Jan. 6, 1937; *Chem. Abs.*, **31**, 5529 (1937).

Making hollow glass bodies. HARTFORD-EMPIRE CO. Ger. 635,507, Sept. 22, 1936; Cl. 32*a*. 15; *Chem. Abs.*, **31**, 827 (1937).

Making multiple-chamber flasks. HAIDEMÜHLE GLASHÜTTENWERKE G.M.B.H. Ger. 640,707, Jan. 11, 1937; Cl. 32*a*. 15; *Chem. Abs.*, **31**, 5529 (1937).

Making sheets of glass. COMPAGNIES RÉUNIES DES GLACES ET VERRES SPÉCIAUX DU NORD DE LA FRANCE. Fr. 803,337, Sept. 28, 1936; *Chem. Abs.*, **31**, 2766 (1937).

Molding plastic materials around glass sheets or objects. PILKINGTON BROS., LTD. Fr. 801,539, Aug. 6, 1936; *Chem. Abs.*, **31**, 517 (1937).

Tempering glass. ALBERT DOUCHE. Fr. 802,590, Sept. 8, 1936; *Chem. Abs.*, **31**, 1973 (1937). SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 803,643, Oct. 5, 1936; *Ibid.*, p. 2767.

Tempering glass objects. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 806,220, Dec. 10, 1936; *Chem. Abs.*, **31**, 4467 (1937).

Tempering glass sheets. AMERICAN SECURIT CO. Brit. 468,471, July 21, 1937(April 6, 1935). Brit. 469,072, July 28, 1937(Feb. 29, 1936).

Tempering sheets of glass. AMERICAN SECURIT CO. Fr. 806,206, Dec. 10, 1936; *Chem. Abs.*, **31**, 4467 (1937).

Tempering tubular glass articles. PILKINGTON BROS., LTD. Ger. 636,476, Oct. 10, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **31**, 827 (1937). See Brit. 448,266 (*Ceram. Abs.*, **15** [9] 274 (1936)).

Borosilicate and cerium glass. H. P. HOOD (Corning Glass Works). Can. 367,461, July 20, 1937 (May 29, 1936); see *Ceram. Abs.*, **16** [4] 117 (1937). G.M.H.

Cellular glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Ger. 634,405, Aug. 27, 1936; Cl. 32*b*. 1; *Chem. Abs.*, **31**, 230 (1937).—Ground unclarified glass, containing a sulfate residue, or a ground mixture of fritted vitrifiable substances is heated in a mold with a reducing agent, *e.g.*, Si, Fe–Si, a carbide, or coal, until gas is evolved from the melt. A suitable glass contains SiO_2 70, Na_2O 14.24, CaO 4.9, Al_2O_3 7, B_2O_3 3.55, and SO_3 0.3 parts, and may be heated with about 43% of SiC. Alternatively, a mixture of ordinary ground glass, powdered quartz, Na_2SO_4, and a reducing agent may be heated. A suitable mixture contains ground glass 90, powdered quartz 3, Na_2SO_4 6, and coal 1%.

Cellular glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Ger. 639,259, Dec. 2, 1936; Cl. 32*b*. 1; *Chem. Abs.*, **31**, 1569 (1937).—A powdered vitreous or vitrifiable silicate composition, containing a substance which evolves a gas when heated, is introduced rapidly into a mold which has been preheated to the softening temperature of the composition. The temperature is maintained until a cellular product results.

Coating glass. ISTVÁN CSÉTI. Hung. 115,475, Dec. 1, 1936; *Chem. Abs.*, **31**, 2378 (1937).—Glass is coated with a gelatin emulsion to which adhesive and coloring agents have been added. The surface of the gelatin may be treated with dyes. The coating is protected against moisture by a film of stearin, oil, lacquer, rubber, casein, etc.

Control of mold opening and closing. EUROPÄISCHER VERBAND DER FLASCHENFABRIKEN G.M.B.H. Ger. 631,038, May 20, 1936 (July 17, 1934); E 45,811, VI/32*a*, Gp. 12; *Jour. Soc. Glass Tech.*, **21** [83] 42A (1937).—The opening of the neck mold or of the tongs holding the neck of the parison is so linked with the closing of the blow mold that the two motions are completed at the same time.

Crucible for continuous fusion of glass. LES FILS DE J. MAY. Fr. 802,847, Sept. 16, 1936; *Chem. Abs.*, **31**, 1973 (1937).

Electric furnace. Y. R. CORNELIUS. U. S. 2,089,689,

Aug. 10, 1937 (April 5, 1934). An electric glassmelting furnace comprises means for passing electric heating current through the molten glass contained therein, a hopper mounted over the molten glass for discharging batch material thereon, and adjustable means for supporting the hopper above the level of the molten glass at such distance therefrom as to variably control the weight of the batch material supported thereby.

Electric furnace. Y. R. Cornelius. U. S. 2,089,690, Aug. 10, 1937 (Jan. 16, 1935). An electric furnace comprises furnace walls and a furnace bottom defining a space adapted for containing a conductive bath formed from a superposed layer of raw material to be treated in the furnace, a plurality of electrodes between which current is adapted to flow through the conductive bath, and electrical connections for the electrodes entering the raw material layer for being cooled thereby.

Electric radiation furnaces. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Brit. 468,997, July 28, 1937 (Oct. 19, 1935).

Furnace for fusing glass. Forges & Ateliers de Constructions Électriques de Jeumont. Fr. 802,598, Sept. 8, 1936; *Chem. Abs.*, **31,** 1973 (1937).

Furnace for glass heated by electric resistances above the glass. Henri J. Bivort. Fr. 803,543, Oct. 2, 1936; *Chem. Abs.*, **31,** 2766 (1937).

Furnace for heating glass for tempering. Pilkington Bros., Ltd. Fr. 802,144, Aug. 28, 1936; *Chem. Abs.*, **31,** 1569 (1937).

Furnaces for the heat treatment of glass objects. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Fr. 807,216, Jan. 7, 1937; *Chem. Abs.*, **31,** 5530 (1937).

Gas-fired regenerative furnace for melting glass. Paul Leonard Geer. Ger. 643,411, April 7, 1937; Cl. 24*c*. 9; *Chem. Abs.*, **31,** 4467 (1937). See Brit. 420,541(*Ceram. Abs.*, **14** [3] 69 (1935)).

Glass. Lennox Hassan. Ger. 636,697, Oct. 13, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **31,** 3226 (1937).—Apparatus for hardening glass by heating and cooling by air currents is described.

Glass. Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Fr. 803,685, Oct. 6, 1936; *Chem. Abs.*, **31,** 2766 (1937). Means for regulating the temperature of the glass in the basins is described.

Glass annealing furnace. Otto Maetz. Ger. 638,642, Nov. 20, 1936; Cl. 32*a*. 34; *Chem. Abs.*, **31,** 3227 (1937).

Glass annealing leer. Carroll Cone (Surface Combustion Corp.). U. S. 2,089,250, Aug. 10, 1937 (Jan. 28, 1935).

Glassblowing. Glaswerke Ruhr A.-G. Ger. 637,861, Nov. 5, 1936; Cl. 37*a*. 7; *Chem. Abs.*, **31,** 5529 (1937). The mold is made of ingot steel poor in C, *i.e.*, containing 1 to 2% C.

Glassblowing pipe. Helmuth Edelmann. Ger. 638,666, Nov. 20, 1936; Cl. 32*a*. 7; *Chem. Abs.*, **31,** 3227 (1937).

Glass composition for electric gaseous discharge devices. Hermann Krefft. U. S. 2,087,762, July 20, 1937 (July 31, 1934; June 15, 1935). A glass has a composition of the order of 60% silica and more than 20% alumina, together with boric oxide, magnesium oxide, and calcium oxide, the glass being free of alkali metal oxides.

Glass factory and improved furnace. August Frederick. U. S. 2,090,444, Aug. 17, 1937 (Oct. 22, 1934). In a glass factory, a basement floor provided adjacent one end thereof with a circular canal and a plurality of mixing containers disposed on the floor in a circular series circumjacent the canal, a glassmelting furnace supported above the floor at the last-named end thereof for receiving the contents of the mixing containers, the furnace being provided with a plurality of glassmelting sections defined by a plurality of radially disposed, internal, spaced walls, tempering leers mounted above the basement floor at the end thereof remote from the mixing containers, down drafts extending downwardly from the spaces between opposed afore-mentioned melting section-defining walls to the circular canal for conducting heat from the furnace to the circular canal, additional canals connecting the circular canal with the leers for conducting heat to the leers, the additional canals including a transverse canal, vertical smoke stacks connected with the transverse canal at the respective opposite ends of the latter, and valves arranged within the transverse canal inwardly from the ends of the latter.

Glass-feeding means. T. C. Moorshead (United Glass Bottle Manufacturers, Ltd.). Can. 367,364, July 13, 1937 (Jan. 30, 1936). G.M.H.

Glass-grinding apparatus. F. B. Waldron (Pilkington Bros., Ltd.). U. S. 2,088,392, July 27, 1937 (Feb. 8, 1935; April 15, 1937). U. S. 2,088,393, July 27, 1937 (Feb. 8, 1935).

Glass-grinding tools. Pilkington Bros., Ltd. Brit. 467,835 and 467,836, July 7, 1937(Feb. 2, 1935).

Glassmaking apparatus. Soc. Anon. des Verreries de Carmaux. Fr. 802,268, Sept. 1, 1936; *Chem. Abs.*, **31,** 1569 (1937).

Glass for mercury-vapor lamps. Patent Treuhand-Ges. für Elektrische Glühlampen m.b.H. (Walter Hänlein and Hermann Krefft, inventors). Ger. 637,269, Oct. 24, 1936; Cl. 21*f*, 82.01; *Chem. Abs.*, **31,** 4073 (1937). Addition to 608,676. The glass contains 25 to 40 SiO_2, 10 to 20 B_2O_3, 25 to 35 Al_2O_3, and 20 to 40% alkaline earth oxide, the sum of the SiO_2 and B_2O_3 contents not exceeding 50%. The glass is suitable for lamps in which the vaporizing Hg body contains 5 to 12% Cs.

Glass molding machines. United Glass Bottle Manufacturers, Ltd. Fr. 801,549, Aug. 6, 1936; *Chem. Abs.*, **31,** 517 (1937). The feeding mechanism is described.

Glass resisting metal vapors. Edwin Berger and Wolfgang Harries (Jenaer Glaswerk Schott & Gen.). U. S. 2,090,098, Aug. 17, 1937(April 7, 1933). A glass resisting metal vapors contains 10 to 40% boric oxide, 10 to 35% alumina, not more than 5% taken together of tetravalent oxides, antimony oxide, arsenic oxide, lead oxide, and alkali oxides, and between 25 and 80% bivalent oxides, zinc oxide being not more than 5%, the amount of bivalent oxides present being such that the sum of $1\frac{1}{2}$ times the percentage of bivalent oxides plus the percentage of alumina equals at least 45.

Glass-smelting furnace. Josef Watzula. Ger. 639,-

573, Dec. 8, 1936; Cl. 32*a*. 1; *Chem. Abs.*, **31**, 4073 (1937).

Glass strengthening method. C. J. PHILLIPS (Corning Glass Works). Can. 367,460, July 20, 1937 (Dec. 20, 1935). G.M.H.

Glassworking apparatus. W. W. TRIGGS (Libbey Glass Mfg. Co.). Brit. 469,178, Aug. 5, 1937 (Jan. 14, 1936).

Hardening glassware in liquid baths. HERZOGENRATHER GLASWERKE BICHEROUX & CIE. G.M.B.H. Ger. 640,176, Dec. 23, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **31**, 2378 (1937). Manipulative features are described.

Heat treating glass. HERZOGENRATHER GLASWERKE BICHEROUX & CIE. G.M.B.H. Ger. 629,151, April 9, 1936 (June 22, 1935); H 144,087, VI/32*a*, Gp. 30; *Jour. Soc. Glass Tech.*, **21** [83] 51A (1937). Addition to Ger. 628,570 (*Ceram. Abs.*, **16** [7] 204 (1937)). In the process described in the parent specification the separation of the jets from the glass sheet is slowly increased during the operation and, for the supply of cooling medium, gradually reduced.

Heat treating glass sheets. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 801,216, July 30, 1936; *Chem. Abs.*, **31**, 517 (1937). Supporting means are described.

Low-expansion glass. HARRISON P. HOOD (Corning Glass Works). Can. 363,020, Dec. 29, 1936; *Chem. Abs.*, **31**, 1570 (1937).—A glass consists approximately of SiO_2 81.0, B_2O_3 16.5, Na_2O 1.3, Li_2O 0.3, Al_2O_3 0.9, and analytically determined F 0.06%.

Luminous discharge lamp. H. P. HOOD (Corning Glass Works). Can. 367,462, July 20, 1937 (May 29, 1936; in U. S., Jan. 8, 1936). G.M.H.

Machine for making hollow bodies from glass tubes. JAKOB DICHTER. Ger. 635,733, Sept. 23, 1936; Cl. 32*a*. 27; *Chem. Abs.*, **31**, 827 (1937).

Machine for the manufacture of glass bottles, etc. F. W. ARMYTAGE. Brit. 468,950, July 28, 1937 (Nov. 15, 1935).

Machine for printing on bottles. J. H. FRIDEN (Anigraphic Process, Inc.). U. S. 2,088,196, July 27, 1937 (Feb. 20, 1935).

Making narrow separating parts of glassware noticeable by coloring. FELIX MEYER. Ger. 635,545, Sept. 18, 1936; Cl. 32*a*. 27; *Chem. Abs.*, **31**, 827 (1937).

Manufacture of glass vessels from tubing. JAKOB DICHTER. U. S. 2,087,947, July 27, 1937 (Nov. 7, 1933).

Manufacture of safety glass. W. W. GROVES (Chemische Forschungsges.). Brit. 467,700, July 7, 1937(June 11, 1936).

Mechanism for severing molten glass. F. L. O. WADSWORTH (Ball Brothers Co.). U. S. 2,090,082, Aug. 17, 1937 (March 21, 1934; June 24, 1935; renewed Jan. 8, 1937).

Method and apparatus for perforating glass bodies. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 468,941, July 28, 1937 (March 18, 1936).

Method of making bubble-free glass. A. E. BADGER (Corning Glass Works). Can. 367,188, July 6, 1937 (March 23, 1936). The batch is fused in the presence of helium, which replaces intersticial air, and is kept at a high temperature in an atmosphere of hydrogen until the helium has diffused from the bubbles. See *Ceram. Abs.*, **15** [7] 205 (1936). G.M.H.

Method of making glass tubes with laminated walls. GLASWERK GUST. FISCHER (Hellmuth Fischer, inventor). Ger. 642,488, March 23, 1937; Cl. 32*a*. 24.02; *Chem. Abs.*, **31**, 4467 (1937).

Method and means for forming glassware. A. J. SMITH (Hartford-Empire Co.). U. S. 2,089,008, Aug. 3, 1937 (Jan. 7, 1936).

Method of producing laminated glass. ADOLF KÄMPFER. Can. 367,264, July 6, 1937 (Oct. 3, 1935). G.M.H.

Mirror. HIRAM W. EDWARDS (Don Baxter, Inc.). Can. 362,808, Dec. 22, 1936; *Chem. Abs.*, **31**, 1570 (1937). An alloy of about 5% Mg and 95% Al is applied to the mirror body, such as glass, by vaporization and condensation in a vacuum chamber.

Molds for blowing glass objects. VERRERIES-GOBELETERIES L'ESPÉRANCE (SOC. ANON.) (Désiré J. Amiable, inventor). Fr. 802,890 and 802,891, Sept. 17, 1936; *Chem. Abs.*, **31**, 1973 (1937).

Molten glass feeding method. T. F. PEARSON (Crown Cork & Seal Co., Inc.). Can. 367,152, July 6, 1937 (April 17, 1933). G.M.H.

Multipart glass article. W. P. ZIMMERMAN AND M. K. HOLMES (Owens-Illinois Glass Co.). Can. 367,475, July 20, 1937 (Jan. 29, 1936). G.M.H.

Nonshatterable glass. WALTER PEGLER (Joseph L. Pegler). Can. 361,603, Nov. 3, 1936; *Chem. Abs.*, **31**, 1571 (1937). Gelatin is soaked in water and liquefied by heat, as plasticizer glycerol is added, a film of the mixture is applied to the surface of a sheet of glass, the film dried by evaporation, the glass immersed in an acid solvent to render the film surface adhesive, a second sheet of glass pressed upon the film, and the laminated glass is removed from the solvent and subjected to heat and pressure.

Nonsplintering glass. CHEM. FORSCHUNGSGES.M.B.H. (Willy O. Herrmann and Erich Baum, inventors). Ger. 634,371, Aug. 25, 1936; Cl. 39*a*. 17.50; *Chem. Abs.*, **31**, 231 (1937). See U. S. 2,033,377(*Ceram. Abs.*, **15** [5] 149 (1936)).

Nonsplintering glass. I. G. FARBENIND. A.-G. (Gerhard Balle and Karl Daimler, inventors). Ger. 638,393, Nov. 14, 1936; Cl. 39*b*. 27; *Chem. Abs.*, **31**, 1174 (1937). As adhesives for use in making nonsplintering glass, use is made of the reaction products of maleic anhydride (I) (or a dicarboxylic acid which yields maleic anhydride) and compounds of the formula RCHOHXR′, where R is H or an alkyl group, R′ is H or an alkyl group, which may contain a COOH or esterified COOH group, and X is —CH_2CHOH—, —CH(Alkyl)CHOH—, or —CH_2CH:CH—. Examples are given of the use of products prepared from I and (*a*) castor oil and (*b*) butylene glycol.

Objects made of tempered glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 803,955, Oct. 13, 1936; *Chem. Abs.*, **31**, 2767 (1937). Various glass objects are made from separate tempered sheets joined together. The places where the joints are to take place may be metallized and the joints made by soldering.

Opacifying glassware. ALLGEMEINE GLÜHLAMPENFABRIKS A.-G. Austrian 148,600, Feb. 10, 1937; Cl. 32*c*; *Chem. Abs.*, **31**, 3657 (1937). The internal surfaces

of hollow glassware are opacified by treatment with a paste prepared from HF and a powdered amorphous organic substance inert to HF, *e.g.*, sintered Bakelite. Products of practically unchanged mechanical properties are obtained.

Portable furnace for tempering glassware. OTTO MARTZ. Ger. 637,456, Oct. 29, 1936; Cl. 32*a*. 28; *Chem. Abs.*, **31**, 827 (1937).

Process of making laminated safety glass. B. J. DENNISON (Pittsburgh Plate Glass Co.). U. S. 2,088,776, Aug. 3, 1937 (March 17, 1936).

Process for undercutting laminated safety glass. J. H. BOICEY (Libbey-Owens-Ford Glass Co.). U. S. 2,089,991, Aug. 17, 1937(March 20, 1935).

Production of serpentine-shaped glass tube. PATENT TREUHAND-GES. FÜR ELEK. GLÜHLAMPEN.M.B.H. Ger. 630,405, May 7, 1936 (June 21, 1935); P 71,438, VI/32*a*, Gp. 27; *Jour. Soc. Glass Tech.*, **21** [83] 46A (1937). A tube of the necessary diameter and wall thickness is produced by drawing in the usual way between a pipe and a punty, and one end is then attached to a winding spindle that is rotated while the tube is fed to it, air being supplied to the interior as required to maintain the bore.

Protecting glass surfaces. COMPAGNIE DES LAMPES. Fr. 805,697, Nov. 26, 1936; *Chem. Abs.*, **31**, 4468 (1937). Glass surfaces such as those of discharge tubes are protected by the application and evaporation of a layer of a dilute solution of HF and appropriate glass powder; this powder is applied before or after the acid or as a suspension in the acid.

Resist for use in the etching of glass. FLORYAN POLASIK (Casimir S. Wiczas). U. S. 2,089,571, Aug. 10, 1937(Jan. 11, 1937). A composition for use as a resist in the etching of glass, etc., is in the form of a pasty mass capable, when diluted and spread upon a glass surface, of drying to a dense, nontacky, adherent film and consists of the following ingredients in substantially the proportions indicated as parts by weight: rosin 2, beeswax 6 to 7, paraffin wax 7 to 8, asphalt 10, pigment 16, varnish 3, turpentine 3, fat 0.5, and a drier in an effective amount.

Rolled glass plates. FERDINAND KINON. Ger. 639,736, Dec. 11, 1936; Cl. 32*a*. 22; *Chem. Abs.*, **31**, 4073 (1937).

Rolling plate glass. FORGES & ATELIERS DE CONSTRUCTIONS ÉLECTRIQUES DE JEUMONT. Ger. 630,663, June 3, 1936; Cl. 32*a*. 34; *Chem. Abs.*, **31**, 239 (1937).

Safety glass. CHEMISCHE FORSCHUNGSGES. M.B.H. Fr. 807,287, Jan. 8, 1937; *Chem. Abs.*, **31**, 5530 (1937). The binders are applied to the glass sheets without the use of any volatile solvent and are rendered plastic by means of appropriate emollients, or, if a volatile solvent is used, it is removed before the binder is applied. Thus, polyvinyl acetate 70 is mixed and heated with dibutyl ester of phthalic acid and when freed from bubbles is pressed at about 120° between the two sheets of glass in the usual press.

Safety glass. SUNEX SÄKERHETSGLAS AKTIEBOLAG (J. Dahle, inventor). Swed. 86,829, July 14, 1936; *Chem. Abs.*, **31**, 1571 (1937). A safety glass consists of two or more sheets of glass and one or more interlayers, each interlayer consisting of at least 3 layers of plastic material, those nearer the glass being of a softer plastic material than the other or others. The layers of the softer plastic have a thickness up to 6 to 10% of that of the glass, and the thickness of the harder layers is at least equal to that of the softer layers. Conveniently, the softer layers consist of artificial resin and the harder layers of a cellulose derivative. The glass sheets may have a thickness of as little as 1 mm.

Safety glass. JOHN WILSON (Triplex Safety Glass Co., Ltd.). Can. 362,310, Dec. 1, 1936; *Chem. Abs.*, **31**, 1570 (1937). The glass sheets are coated with a solution of gelatin, the gelatin is dried in an atmosphere of relative humidity 33%, there is applied a 5% solution in 75 to 90% aqueous acetone of a secondary cellulose acetate prepared by boiling for about 2 hr. in secondary cellulose acetate having an acetyl value of 35.5 to 39% with a mixture of HCl and H_3PO_4(*N*/10 to *N*/12), the coating is dried at about 30° in an atmosphere of relative humidity 33%, the sheets of glass are assembled with a sheet of cellulose acetate plastic in a liquid bath maintained at about 45°, the assembly is subjected to pressure in a squeegee, and the union is completed by pressure in an autoclave.

Safety glass for automobiles. CHEMISCHE FORSCHUNGSGES. M.B.H. (Erich Baum and Willy O. Herrmann, inventors). Ger. 638,709, Nov. 21, 1936; Cl. 39*a*. 17.50; *Chem. Abs.*, **31**, 3228 (1937). Glass sheets of less than 1 mm. strength and an intermediate layer of greater strength are used. Thus, two glass sheets of 0.15 mm. strength are stuck outside a celluloid sheet of 0.6 mm. strength by polyvinyl acetate, by hot pressing.

Silica for glass manufacture. E. N. HALTON FYLES. Can. 362,327, Dec. 1, 1936; *Chem. Abs.*, **31**, 1569 (1937). Grains of SiO_2 and foreign material cemented together are introduced into a rotary drum, sufficient water is added to produce a paste-like mass, breakers are introduced, and the drum is rotated to bring the breakers into intimate contact with all parts of the mass to break down the material into individual grains and comminuted foreign material; the latter acts to scour the grains to remove other adhering particles of the foreign material.

Silica for manufacture of ultra-violet transmitting glass. WERNER DUSING AND JOHANN ENSZ (Canadian General Electric Co., Ltd.). Can. 362,558, Dec. 15, 1936; *Chem. Abs.*, **31**, 1569 (1937). Silicic acid is precipitated from technical water-glass by acids, and the precipitate is washed with dilute H_2SO_4 mixed with H_2O_2 until the titanic acid and Fe oxide contents are less than 0.005%.

Tempered glass. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Brit. 468,944, July 28, 1937 (April 6, 1936).

Tunnel furnaces for slow cooling of glass objects. MAURICE H. V. DELOT AND G. A. DELACROIX. Fr. 805,646 and 805,647, Nov. 25, 1936; *Chem. Abs.*, **31**, 4467 (1937).

Structural Clay Products

New brickworks. HUNZIKER, LTD. *Ind. Chemist*, **12** [141] 456 (1936).—In sand-lime brick made by the Hunziker process a carefully selected crushed flint is used producing a brick of exceptionally dense structure, high mechanical strength, low porosity, and devoid of moisture movement. H.E.S.

Tested brick for road paving. A. E. BLIZZARD. *Trans. Ceram. Soc.*, **36** [3] 98–109 (1937); see *Ceram. Abs.*, **16** [3] 90 (1937). R.H.H.P., JR.

STANDARD AND BULLETIN

Dimensions of Drain-Fittings. British Standard Specification No. 539—1937. BRITISH STANDARDS INST., London. Price 2s. The chief dimensions of the important parts of straight and tapered pipes, junctions, channel bends, insets, interceptors, traps, gullies, hoppers, raising pieces, and rain-water shoes to enable them to conform to the British Standard Specification are stated and illustrated. The materials of which these articles are made are salt-glazed ware, salt-glazed glass, and enameled fire clay. A.B.S.

Houses. JOAN WOOLLCOMBE. Clay Products Technical Bureau of Great Britain. 20 pp. First considerations are finance, the architect, site and placing on site for sunshine, and subsoil. Brick and tile are strongly recommended for walls and roof. Reinforced brickwork immediately below the roof is suggested as protection against the new light and terrifying incendiary bomb. Brick bonds and different types of tile shapes are illustrated. Diagrams indicate the proper location for damp-proof courses in the masonry. Recommendations for mortar and many construction details are given. F.T.HEATH, JR.

PATENTS

Apparatus for batching and mixing cellular clay products. J. B. RITTGERS AND C. S. MATHENY (National Fireproofing Corp.). U. S. 2,090,503, Aug. 17, 1937(Aug. 26, 1932). A batching and mixing machine comprises a mixing chamber, a plurality of graduated materials containers above the chamber, a liquid measuring device connected to the chamber, a rotary disk disposed between the mixing chamber and materials containers having graduated openings adapted to register with the openings of the containers, valve means for the liquid measuring device, means operative in response to rotation of the disk for opening the valve, means to cause the fluid to flow to the chamber, and means for rotating the disk to successively align its openings with the several materials containers and to actuate the liquid measuring valve.

Brick grab. E. R. HERSHEY (Lancaster Iron Works). U. S. 2,088,519, July 27, 1937 (Nov. 18, 1936).

Brick tie. J. J. FITZ GERALD. U. S. 2,089,253, Aug. 10, 1937 (Jan. 11, 1937).

Brick wall construction. C. C. CAIN. U. S. 2,087,883, July 27, 1937 (Feb. 20, 1936).

Building brick. D. A. WALLACE. U. S. 2,088,625, Aug. 3, 1937(Dec. 13, 1935). In combination, a reinforced channel member, a plurality of brick, and means for retaining the brick in the channel member whereby the plurality of brick may be handled as a unit, the channel members having laterally extending flanges adapted to be engaged by securing elements for attaching the channel members to a supporting structure, the flanges also constituting means for spacing apart superposed channels a uniform distance to provide mortar spaces therebetween.

Building tile. L. M. CHRISTIE AND C. H. BELL (National Fireproofing Corp.). U. S. 2,090,285, Aug. 17, 1937 (March 23, 1935).

Instrument for cutting brick. D. J. COFFEY. U. S. 2,090,471, Aug. 17, 1937 (Feb. 10, 1937).

Refractories

Alunite for production of alumina. G. V. LABUTIN AND S. G. KOLTYPIN. *Legkie Metally*, **5** [10] 41–47 (1936); *Chem. Abs.*, **31**, 3641 (1937).—Alunite, crushed to −60 mesh and calcined at 550°, was treated with a 5% NH_4OH solution to dissolve the sulfate. The Al_2O_3 was recovered by digesting with NaOH solution at 95 to 100°. About 85% of the Al_2O_3 was recovered, with an Al_2O_3:SiO_2 ratio of 200.

Carbon, a refractory and antiacid material. RENÉ MAIRE. *Céramique*, **40** [591] 93–98 (1937).—M. reviews the properties of carbon in various allotropic states, such as diamond, graphite, and amorphous carbon. The physical properties, heat, fusion, volatilization, density, hardness, specific heat, thermal conductivity, and absorption capacity are examined. With regard to chemical properties, the effect of oxygen, oxidizing mixtures, effect of oxides and silicates, and attack by acids and organic solvents are dealt with. The properties of agglomerates of amorphous carbon, their industrial uses, especially in electrochemistry, electrometallurgy, and siderurgy, and their application as antiacid material for lining various apparatus, and Raschig rings are discussed. From the refractory point of view, carbon agglomerates can be used up to 2500°C (in reducing atmosphere); they have an excellent resistance to sudden temperature changes and to attacks of basic or acid slag. Their use as antiacid material because of their resistance to a number of chemical agents is relatively recent. M.V.C.

Chemical compositions and properties of refractories. L. LOSANA, C. GORIA, AND G. ROSSIGNOLI. *Chimica & Industria*, **19** [2] 57–64 (1937).—The relation between chemical composition of a refractory material and its properties was investigated. Refractories with an essentially alumina base do not give consistent test results with regard to melting point if tested with the Seger cone. Materials poor in silica give correct data on temperatures of deformation. Thermal expansion diminishes in materials with 20 to 40% Al_2O_3 and in some with up to 60% Al_2O_3. Permeability to gas at high temperatures is much stronger in brick with higher contents of alumina; the absolute value depends on air, H, and CO_2, but this can usually be neglected. The corrosion resistance to basic slags and

mixtures of borax and sodium carbonate increases rapidly for an Al_2O_3 content over 50%. Apparatus are described to test fusion and softening points under load. M.H.

Chrome-alumina brick: I. T. R. Lynam and W. J. Rees. *Bull. Brit. Refrac. Research Assn.*, No. 29 (March, 1933); reprinted in *Trans. Ceram. Soc.*, **36** [3] 110–32 (1937).—The effect of the addition of alumina or calcined Indian bauxite to a chrome brick batch is described. Higher mechanical strength, indicated by refractoriness-under-load and high-temperature tensile tests, is obtained with increasing bauxite content. A more viscous bond results, and coarse grading of the bauxite is found to reduce the amount of melt formed as a result of chemical reaction. Additions of more than 50% bauxite lower the resistance to slag attack. Additions of bauxite to chromite decrease the thermal expansion and the spalling tendency. Microscopic examination of the trials shows the growth of needle-like crystals of corundum with the Cr_2O_3 replacing the Al_2O_3. **II.** *Bull. Brit. Refrac. Research Assn.*, No. 33 (March, 1934); reprinted in *Trans. Ceram. Soc.*, **36** [3] 133–36 (1937).—Service trials of a series of brick molded from high-grade Turkish chrome ore and Demerara bauxite show that conditions in the basic open-hearth furnace are too severe for chrome-bauxite brick. The viscosity of the bond is not great enough to mask the low "start to fail" point, 1430°C for the laboratory trials and 1370°C for the manufactured brick as indicated by refractoriness-under-load tests. Test brick built into the wall of a tin-smelting furnace are reported to give good service. R.H.H.P., Jr.

Decomposition of mullite. Vladimir Škola. *Keram. Rundschau*, **45** [17] 188–90; [18] 200–202; [19] 212–13, 215 (1937); see *Ceram. Abs.*, **15** [11] 335 (1936); **16** [3] 86 (1937). F.E.V.

Development of American power plants. A. G. Christie. *Mech. Eng.*, **58** [9] 539–61 (1936).—The trend in refractory practice in power plants is briefly discussed. F.G.H.

Discussion of recent developments in refractories. C. E. Moore. *Metal Ind.* [London], **48**, 36–37 (Jan. 10, 1936); *Metals & Alloys*, **7** [10] MA496 (1936); for abstract see *Ceram. Abs.*, **15** [5] 154 (1936).

Emissivities of refractory materials. R. H. Heilman. *Mech. Eng.* **58** [5] 291–92 (1936).—The calibration and operation of equipment for the determination of the emissivities of various refractory materials are described. Numerous tests indicate conclusively that color has a marked influence on the emissivity of surfaces at temperatures above 500°F. Chemical composition also has considerable influence on the emissivity. Emissivity decreased with an increase in temperature for all the colors of refractory materials investigated with the exception of black. White and light buff refractories showed rapidly decreasing emissivity with temperature increase. Illustrated. F.G.H.

Experiment on a furnace roof arch. C. Wolstencroft. *Heat Treating & Forging*, **22** [5] 254, 257 (1936).—An arch 13 ft. 6 in. between piers and 18 in. wide was cast of refractory concrete. Two 1 1/8 in. round bars, bent "U" shape, were cast into the concrete to serve as lifting eyes, but expansion has caused trouble, and their elimination is recommended. Old firebrick aggregate not over 1 1/2 in. and screened fines were used, the proportions being 1 Lumnite, 2 1/2 coarse, 1 fines, by volume, with sufficient water to give a soft plastic mix. This arch has been in service for a year and is still in good condition. A firebrick arch would have been replaced twice in this time. S.S.

Manufacture of fired clay grog. Anon. *Brit. Clayworker*, **46** [543] 109–10 (1937).—The utilization of the Herreshoff multiple-shelf furnace for preparing grog successfully and cheaply is described. The temperature of firing was 800°C, the capacity 50 tons of clay per 24 hr., and the size 16 ft. 6 in. in diameter, with 7 hearths. The fuel used was 5 to 6% of the fired weight of the grog. R.A.H.

Method for preparation of alumina: II, Preparation of alumina from basic aluminum acetate. Shohei Uno. *Waseda Applied Chem. Soc. Bull.*, No. 27, pp. 12–17 (*Abstracts* (in English) 2) (1936); *Chem. Abs.*, **31**, 2755 (1937).—Filtration and washing of $Al(OH)(AcO)_2$ precipitate, prepared by heating a solution containing $Al_2(SO_4)_3$ (0.3 to 0.4 mol.) and $AcONH_4$ at the ratio of 1:6 or 7 and $AcONH_4$ and AcOH at the ratio of 1:0.5 at 100° for 1 hr., is easy, and the recovery of Al reaches 95%. Addition of more $AcONH_4$ than this ratio causes the formation of a difficultly filterable precipitate, while addition of less than this ratio causes a decrease in the amount of precipitate. The $Al(OH)(AcO)_2$ precipitate turns black on heating to 250°, but heating at 300 to 450° by blowing steam in expels AcOH completely and gives Al(OH)O. $Al(OH)(AcO)_2$ dried at 100°, after treatment with 0.5 to 1.0% aqueous NH_4OH at room temperature, gives powdered $Al(OH)_3$; using stronger aqueous NH_4OH gives quicker results but the product has a tendency to become gelatinous.

Mixtures of chromite and Grecian magnesite: I. T. R. Lynam and W. J. Rees. *Bull. Brit. Refrac. Research Assn.*, No. 29 (March, 1933); reprinted in *Trans. Ceram. Soc.*, **36** [3] 137–51 (1937).—A series of mixes of chrome ore and calcined Grecian magnesite was made, and it was found that mechanical strength at high temperatures increases with magnesite content and that a 1:1 batch has a fail point equal to that of calcined magnesite. The high thermal expansion of magnesite can be decreased by additions of chromite. Friability resulting from the use of coarse-grained calcined Grecian magnesite can be decreased by finer grinding and by the use of dead-burned Austrian magnesite or by the introduction of 2.5% feldspar as a flux. All the mixtures tested were highly resistant to the action of basic slags. **II.** *Bull. Brit. Refrac. Research Assn.*, No. 33 (March, 1934); reprinted in *Trans. Ceram. Soc.*, **36** [3] 152–72 (1937).—The results of service trials in the basic open-hearth furnace and the Héroult electric furnace of test brick manufactured from coarse-grained, 30-mesh, and 50-mesh calcined Grecian and Austrian magnesite and Rhodesian chrome ore are reported. The addition of magnesite to a chrome brick fired at high temperatures to promote necessary conversion improves its durability and mechanical strength at elevated temperatures. The addition of 10% talc concentrate to a 3:1 chrome-magnesite mix subsequently fired at 1560°C produces a brick of high strength with a uniform distribution of forsterite. Nonuniform distri-

bution of the crystalline bond leads to increased friability. R.H.H.P., JR.

Refractories for electric furnaces. H. KIRCHRATH. *Chem.-Ztg.*, **61**, 293–96 (1937); *Chem. Abs.*, **31**, 4903 (1937).—Refractory specifications include high melting point, mechanical strength, resistance to abrupt temperature changes, chemical inertness, no shrinkage at high temperature, low heat, and low electrical conductivity. The chemical compositions of grog, silica, magnetite, chromite, C, Si carbide, and zirconite are tabulated together with their resistance to basic materials (slags), acids (SiO_2, HF), reduction and oxidation, and molten metals. Heat-insulating materials, such as infusorial earth, and metallic and nonmetallic resistors are discussed.

Refractory materials. J. H. PARTRIDGE. *Jour. & Record Trans. Junior Inst. Engrs.*, **46**, 307–26 (April, 1936); *Metals & Alloys*, **8** [1] MA18 (1937); see *Ceram. Abs.*, **15** [5] 151 (1936).

Sillimanite, its varieties and existence in France. V. CHARRIN. *Céram., Verrerie, Email.*, **4** [8] 313–15 (1936). —Sillimanite is an anhydrous monosilicate of aluminum and is considered a variety of disthene and andalusite. These three minerals are rare and exist principally in mica schists or accompanied by staurolite (ferriferous silicate of alumina). They are ideal for temperatures of 1800° and their great durability has put them among the best of superrefractories. Because of the high cost of these refractories and until artificial production is perfected, new natural sources are being sought. Deposits in France are listed. M.V.C.

Suspended walls, arches, and water walls. R. B. PURDY. *Power*, **80** [3] 135–38 (1936).—Twenty-nine examples of refractory walls and arches are described and illustrated. F.G.H.

Symposium on refractories testing: I, Work of the American Society for Testing Materials on refractories. C. E. BALES. *Bull. Amer. Ceram. Soc.*, **16** [8] 317–18 (1937). **II, Methods of testing insulating refractories.** W. C. RUECKEL. *Ibid.*, pp. 319–21. **III, Panel spalling tests on insulating brick and insulating fire brick.** W. RAYMOND KERR. *Ibid.*, pp. 322–28. **IV, Practical service testing of refractories for alloy steel melting.** EDWARD E. CALLINAN AND GILBERT SOLER. *Ibid.*, pp. 329–34. **V, Navy Department method of testing refractory linings for Naval boilers.** F. M. MCGEARY. *Ibid.*, pp. 335–39.

Thermal and electrical conductivities of a sample of Acheson graphite from 0° to 800°C. R. W. POWELL. *Proc. Phys. Soc.* [London], **49** [4] 419–26 (1937).—Determinations have been made of both the thermal and the electrical conductivities of a sample of Acheson graphite over the temperature range 0° to 800°C. The thermal conductivity, K, is found to decrease from a value of 0.40 unit at 0°C to 0.16 at 800°C, the rate of decrease being greater at lower temperatures. The electrical conductivity has, at 0°C, a value of $1218\Omega^{-1}/cm.^{-1}$, which increases to a maximum value of 1518 at 450°C and decreases to 1444 at 800°C. See *Ceram. Abs.*, **15** [11] 341 (1936). L.E.T.

BULLETIN

Possibility of production of aluminum in Bombay. M. S. PATEL. *Dept. Ind., Bombay Presidency, Bull.*, No. 10, 27 pp. (1936); *Chem. Abs.*, **31**, 2142 (1937).—A deposit of high-grade bauxite has recently been discovered on Tungar Hill in the Thana district within 30 miles of the city of Bombay. The high-grade material contains Al_2O_3 55 to 59, Fe oxide 5 to 11, TiO_2 2 to 7, and SiO_2 0.3 to 0.8%; loss on ignition is 28 to 32%. Treatment of the bauxite on a laboratory scale by the Bayer process yielded alumina containing Al_2O_3 99.34, Na_2O 0.25, Fe oxide 0.03, and SiO_2 0.02%; loss on ignition 0.28%. Profitable production of Al from this deposit seems to be possible.

PATENTS

Basic refractory product. LOUIS VEAUX. Fr. 807,527, Jan. 14, 1937; *Chem. Abs.*, **31**, 5532 (1937). A product for lining metallurgical furnaces is composed of a crude basic mineral, such as crude dolomite, mixed with a flux. A binder such as a refractory earth may be added.

Binder for refractory material. NORMAN P. PITT AND ALAN F. GILL. Fr. 807,384, Jan. 11, 1937; *Chem. Abs.*, **31**, 5532 (1937). The binder contains an alkali silicate with a certain proportion of an alkali phosphate.

Ceramic products. MAGNESITAL G.M.B.H. Fr. 802,518, Sept. 7, 1936; *Chem. Abs.*, **31**, 1974 (1937). In making ceramic products resistant to quick cooling, particularly magnesian brick, strongly refractory materials (Cr ore, Cr_2O_3, Mn ore, talc), with the exception of clay, are added to the basic material in amount not above 8 to 10%. The basic material contains large grains (above 0.8 mm.), medium grains (0.1 to 0.8 mm.), and fine grains (below 0.1 mm.) in the proportion of 5:2:3. The amount of large and small grains may be increased or reduced by $^1/_3$ from this proportion.

Ceramic ware. DIDIER-WERKE A.-G. Ger. 633,920, Aug. 12, 1936; Cl. 80*b*. 12.01; *Chem. Abs.*, **31**, 518 (1937). Powdered crude or weakly preheated clay is treated with Al compounds such as solutions of aluminates or Al_2O_3 salts of organic acids, mixed with water and a binding agent, molded to form ware, and fired.

Furnace port. S. A. FORTER (Forter-Teichmann Co.). U. S. 2,088,783, Aug. 3, 1937 (Dec. 5, 1936).

Magnesite brick for constructing rotary kilns. VEITSCHER MAGNESITWERKE A.-G. Austrian 149,181, April 10, 1937; Cl. 80*c*.; *Chem. Abs.*, **31**, 5530 (1937). Constructional features are described.

Merwinite refractories. H. C. LEE (Non-Metallic Minerals, Inc.). U. S. 2,089,970, Aug. 17, 1937 (Dec. 29, 1934). A refractory product comprises a plurality of refractory ingredients, a substantial one of which is merwinite.

Method of producing aluminium oxide. A. S. BURMAN. Brit. 469,061, July 28, 1937 (July 29, 1935).

Porous refractory brick. I. SETTERBERG. Swed. 87,709, Oct. 20, 1936; *Chem. Abs.*, **31**, 1572 (1937). The raw material before shaping is treated with water and a substance which generates a gas in the presence of water; before this treatment it is mixed with finely divided SiO_2 and CaO, which on subsequent drying form a binding agent for the raw material.

Production of magnesite brick. MAGNESIT-INDUSTRIE AKT.-GES. Brit. 468,456, July 21, 1937 (Jan. 10, 1935).

Production of refractory shaped bodies or refractory linings. A. SPRENGER. Brit. 468,765, July 21, 1937 (Dec. 18, 1935).

Refractories. NON-METALLIC MINERALS, INC. Fr. 804,367, Oct. 22, 1936; *Chem. Abs.*, **31**, 3658 (1937). MgO, CaO, and SiO_2 are heated so as to produce periclase and a durable Ca orthosilicate. The SiO_2 is in a finely divided or hydrated state. Impure MgO, with or without dolomite, may be used, and the heated material may contain small amounts of oxides of B, P, or Cr.

Refractory body. KARL SCHWARTZWALDER (General Motors Corp.). Can. 362,445, Dec. 8, 1936; *Chem. Abs.*, **31**, 1572 (1937). Ceramic bodies, *e.g.*, insulators for spark plugs, are prepared by converting highly refractory nonplastic material together with Bakelite and a lubricant, *e.g.*, calcined alumina 88, Bakelite 10, and lubricant 2%, to a fine powder, the major portion having a grain size of 0 to 5 μ, agglomerating the material, molding under a pressure of 10,000 lb./sq. in. with insufficient heat to set the Bakelite, assembling on a center post, molding under heat and a pressure of 25,000 to 100,000 lb./sq. in. to set the Bakelite, removing the center post, and firing at temperatures to expel the Bakelite and recrystallize the material into a dense, nonporous structure.

Refractory body comprising chromite, spinel, and mullite. G. E. SEIL. Can. 367,279, July 6, 1937 (Oct. 30, 1936); see *Ceram. Abs.*, **16** [3] 92 (1937). G.M.H.

Refractory material. WILHELM BRANDES. Ger. 633,718, Aug. 5, 1936; Cl. 80*b*. 8.13; *Chem. Abs.*, **31**, 519 (1937). The refractory for smelting Zn consists of clay and beryl, $3BO{\cdot}Al_2O_3{\cdot}6SiO_2$.

Refractory material. VICTOR M. GOLDSCHMIDT. Ger. 632,543, July 10, 1936; Cl. 80*b*. 8.08; *Chem. Abs.*, **31**, 829 (1937). Addition to 631,010 (*Ceram. Abs.*, **16** [7] 210 (1937)). The process of Ger. 631,010 is modified in that the proportion of MgO or like Mg compound is increased sufficiently to react with the compounds of Al, Mn, Cr, Ni, and like metals which may be present in the mineral starting material. The process may be effected in an alternately oxidizing and reducing atmosphere, but fusion of the mixture must be avoided.

Refractory material. W. C. LEONARD. Australian 22,849/35, Dec. 31, 1936; *Chem. Abs.*, **31**, 3658 (1937). Refractory material in which may be embedded electrical heating wires consists of granulated porcelain, powdered kaolin, and a solution of Na silicate.

Refractory material. NON-METALLIC MINERALS, INC. Fr. 805,091, Nov. 10, 1936; *Chem. Abs.*, **31**, 3658 (1937). A refractory is made by heating CaO and SiO_2 in the proportions of 1 to 1.4 with MgO which represents at least 12% of the mixture. The proportions are such that merwinite and periclase are obtained.

Refractory material. VEITSCHER MAGNESITWERKE A.-G. Ger. 637,812, Nov. 4, 1936; Cl. 80*b*. 8.01; *Chem. Abs.*, **31**, 5531 (1937). A fireproof mass which can be molded without previous firing consists of highly heated MgO, Cr ore in small amounts compared with the MgO, up to 5% of clay, a small amount of water, and an acid electrolyte such as $NaHSO_3$.

Refractory product. CLARENCE J. BROCKBANK AND SOC. D'ÉLECTROCHIMIE, D'ÉLECTROMÉTALLURGIE ET DES ACIÉRIES ÉLECTRIQUES D'UGINE. Fr. 800,855, July 21, 1936; *Chem. Abs.*, **31**, 232 (1937). Graphite and (or) SiC (with an organic binder if desired) are mixed with 5 to 10% or more of one or more metals (Fe, Cr, Ni, Mn, V) capable of reacting with the SiC to form a metal silicide. The metals may be present as such or as alloys or in the form of their oxides, in which case a reducing agent such as a F compound is added to cause reduction at a low temperature. The products are fired at about 1100°.

Refractory product. SOC. ANON. DES MANUFACTURES DES GLACES & PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY & CIREY. Fr. 800,779, July 18, 1936; *Chem. Abs.*, **31**, 232 (1937). A refractory product is obtained with zircon (or Zr silicate) and refractory oxides in such proportions that, when the mixture is heated to 1500°, all the SiO_2 resulting from the decomposition of the zircon combines with the oxides. Thus the mixture may contain zircon 20 to 40 and corundum 80 to 60 or MgO 80 to 60%.

Silica brick. HERMANN SALMANG AND BENNO WENTZ. Ger. 634,363, Aug. 25, 1936; Cl. 80*b*. 8.06; *Chem. Abs.*, **31**, 1974 (1937). Addition to 555,767 (*Ceram. Abs.*, **12** [3] 114 (1933)). The method of 555,767 for making the brick from quartzite, sulfite lye, $Ca(OH)_2$, Na_2O, soda and Fe_2O_3, etc., is modified by heating the brick in a moist atmosphere to 50 to 100° before drying and firing.

Terra Cotta

Engobes and glazes for fireclay ware. ANON. *Keram. Rundschau*, **45** [3] 25–26 (1937).—The process of manufacture is completely described; 4 or 5 layers of engobes, with organic and aniline additions, are applied on dried raw ware; after drying, 2 to 3 layers of white or colored glazes are applied. Compositions of engobes and glazes are given. The opacifier of the glaze is usually 6% tin oxide. F.E.V.

PATENT

Glazed tile. FRITZ KNAPP. Austrian 149,381, April 26, 1937; Cl. 80*f*; *Chem. Abs.*, **31**, 5531 (1937). The firing of tile before they are glazed is effected under such conditions that only the surface to which the glaze is to be applied is completely fired. Glazing is then completed in the usual way. Apparatus is described.

Whiteware

Characteristics of steatite bodies. L. E. THIESS. *Jour. Amer. Ceram. Soc.*, **20** [9] 311–14 (1937).

Glaze defects and their correction. BERDEL. *Keram. Rundschau*, **45** [7] 70–71; [9] 96–98 (1937).—B. discriminates peeling before melting of glaze in the glost oven, peeling after melting, and crazing (hairlines). Peeling with edges rounded off is usually due to the drying contraction of the glaze being less than that of the nonbiscuited body. Some clay or kaolin should be added to the glaze. Eventually, the drying contraction of the glaze may be too high,

whether the body is biscuited or not. The presence of insulating layers due to algae also causes this kind of peeling. Peeling with sharp edges is rather uncommon and is due to the cooling contraction of the body being greater than that of the glaze. A reduction of the quartz content in the body and of silica in the glaze is the remedy. Crazing is the opposite defect. An increase of quartz in both body and glaze and, for low-fired ware, of lime or magnesite will reduce hairlines. F.E.V.

Improving Poshan porcelain. KING-KONG HU, STEIN TSUNG TSIEH, AND PAO-CHIA LIU. *Nat. Shantung Univ., Dept. Chem. Lab., Research Repts.*, No. 5, pp. 22–49 (1936); *Chem. Abs.*, **31**, 1971 (1937).—Raw materials employed in the Poshan district, Shantung Province, China, are suitable, but scientific development is needed. Small-scale experiments are reported.

Opaque hard porcelain glazes. W. STEGER. *Ber. Deut. Keram. Ges.*, **17** [10] 484–95 (1936).—In a hard porcelain glaze of the composition 10 potash, 15 alumina, and 75% silica, raw beryllium oxide, zirconium dioxide, and yttrium oxide act as opacifiers on firing to Seger cone 14 to 15. White, enamel-like glazes are obtained by substituting these oxides for 5 to 2.5% of the potash. The same percentages of thorium oxide make the glaze too hard to melt; cerium oxide makes the glaze blistery or foamy, while titanium oxide produces discolored gray glazes. The glaze with 2.5% beryllium oxide has the lowest thermal expansion up to 600°. E.J.V.

Utilization of casting scraps. J. W. BENTLEY. *Trans. Ceram. Soc.*, **36** [3] 75–83 (1937).—The principal troubles caused by the excessive use of casting scraps are thinning of the slip and settling of coarse particles; increased lawning, pressing, and casting times; and drying cracks. These faults, which are attributed to the presence of deflocculants and dissolved plaster in the scraps, can be corrected by adjusting the deflocculant additions to the casting slip so as to counteract the influence of the recovered scrap material present. R.H.H.P., JR.

PATENTS

Ceramic materials. FELIX SINGER. Ger. 605,237 Nov. 7, 1934; Cl. 80*b*. 8.08; *Chem. Abs.*, **29**, 1223 (1935). See Brit. 282,403 (*Ceram. Abs.*, **7** [5] 304 (1928)).

Ceramic materials. FELIX SINGER. Ger. 637,916, Nov. 6, 1936; Cl. 80*b*. 8.08; *Chem. Abs.*, **31**, 3228 (1937). Addition to 605,237(see preceding patent). Products having a low coefficient of expansion are made by heating steatite or like Mg compound with a compound of Al, as described in Ger. 605,237, but the process is modified in that the maximum heating temperature is maintained until the vitreous phase, characteristic of the products of Ger. 605,237, has been converted into a crystalline phase. A heating period of at least 30 min. is generally necessary.

Electric discharge vessels made of ceramic material and process for their production. J. T. SHEVLIN (Siemens & Halske Akt.-Ges.). Brit. 467,720, July 7, 1937 (Nov. 9, 1936).

Fog and dust insulator. B. A. PLIMPTON (Locke Insulator Corp.). U. S. 2,088,433, July 27, 1937 (Aug. 24, 1933).

Equipment and Apparatus

Constant-weight feeder. INTERNATIONAL COMBUSTION, LTD. *Ind. Chemist*, **12** [137] 303 (1936).—A constant-weight feeder consists of a traveling belt on a pivoted frame suspended below the feed hopper so that any variation in the weight on the belt will tilt the frame, which in turn moves the feed gate through appropriate linkage. When the weight on the belt increases, the frame tilts down and the feed gate is lowered. When the weight decreases the belt and frame rise and the gate is opened wider, increasing the quantity of material on the belt. A constant weight is thus maintained. Feeding by constant volume is said to lead to variations of between 10 and 40% when the material to be fed is nonuniform in character; hence, considerable interest is being shown in constant-weight feeders. The above machine takes less than $^1/_4$ h.p. to feed at rates up to 100 tons/hr. Illustrated. H.E.S.

Cutting fluids applied to the turning of Monel metal. O. W. BOSTON AND W. W. GILBERT. *Trans. Amer. Soc. Mech. Engrs.*, **58** [8] 685–89 (1936).—In cutting Monel metal, high-speed steel tools fail by cupping on the face and abrasion on the flank below the cutting edge. A tool with $^1/_8$ in. nose radius and 15° side rake angle proved superior in dry turning to one with $^3/_{64}$ in. nose radius and 22° side rake angle, for all values of tool life less than 120 min. For shallow thick cuts of 0.050 in. at a feed of 0.0255 in., the second tool is superior for a tool life of more than 120 min. A deep thin chip of a given area allowed a higher cutting speed for a given tool life for both tool shapes. In most cases, an emulsion of 1 part of soluble oil to 15 parts of water produced slightly longer tool life than a 1 to 50 emulsion. An emulsion seems preferable to the sulfurized mineral oil. The type of fluid used did not seem to affect the machined finish. The cutting forces are highest when dry, intermediate with an emulsion, and lowest with a sulfurized mineral oil. When dry, the tangential force is from 46 to 62% higher than when dry cutting S.A.E. 3135 annealed steel. S.S.

Determination of plasticity of clay. B. G. ZAPROMETOV AND A. SHAMSIEV. *Byull. Sredne-Aziat. Gosudarst. Univ.*, No. 19, pp. 29–32 (1934); *Chem. Abs.*, **31**, 4855 (1937).—Apparatus is described.

Efficient lubrication of cement mill machinery. M. J. HELMES. *Concrete* [Cement Mill Ed.], **43** [8] 35–36 (1935). W.D.F.

Illumination device for microscopes. CARL ZEISS. *Jour. Sci. Instruments*, **14** [5] 181–82 (1937).—This pancratic condenser contains in a single tube all that is required for correct illumination of both bright and dark fields at varying magnifications. It contains a small 4-watt bulb and a condenser of 1.4 maximum aperture. A single adjustment adapts it to objectives of 0.16 to 1.40 numerical aperture in bright field. For dark-field work, a central stop is inserted and immersion oil is placed on the top lens of the condenser. This allows the device to be used in dark field with an objective of 0.65 numerical aperture or smaller. Price £20 8s. Illustrated. J.L.G.

Industrial apparatus for the determination of thermal conductivity of metals at temperatures up to 900°C. G.

RANQUE, P. HENRY, AND M. CHAUSSAIN. *Congr. Internat. Mines, 7th Session, Oct., 1935, Met. Sec.*, **2**, 303–309 (1936); abstracted in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 91, p. 24 (1936).—The apparatus and method are described, and results are given showing the variation in the conductivity with temperature for Cu, Fe, Ni, and 18–8 steel.

Laboratory apparatus for the magnetic separation of minerals. B. GRANNIG. *Metall & Erz*, **34** [11] 280–82 (1937).—A description of a small apparatus and its operation is given. Illustrated. L.T.B.

Practical de-airing. JOHN H. ISENHOUR. *Jour. Amer. Ceram. Soc.*, **20** [9] 314–16 (1937).

Recording microphotometer. P. J. KIPP EN ZONEN. *Jour. Sci. Instruments*, **14** [5] 183–84 (1937).—The instrument described is an improved form of the Moll microphotometer type A. Price £840. Illustrated. J.L.G.

Soft soap for ceramic purposes. CHEM. LAB. WELWART. *Seifensieder-Ztg.*, **61** [36] 695 (1934).—A specimen of a soft soap for ceramic purposes examined by the laboratory proved, by the constants of the liberated fatty acids, to be a pure soft linseed oil soap. E.ST.

Synchronous or induction motors. S. L. HENDERSON. *Power*, **80** [8] 430–31 (1936).—H. compares the characteristics of synchronous and induction motors and indicates the classes of service for which each is best suited. F.G.H.

Testing seive shaker. INTERNATIONAL COMBUSTION, LTD. *Ind. Chemist*, **12** [139] 383 (1936). H.E.S.

Thermal conductivity of modern ceramic insulating material. W. STEGER. *Stemag-Nachr.*, No. 14 (1936); abstracted in *Referat. Silikatliteratur*, **3** [10] 3337 (1936).—Various apparatus used to determine the figure of thermal conductivity are described. See *Ceram. Abs.*, **15** [9] 282 (1936). M.V.C.

Uses and limitations of respiratory protective equipment. PHILIP DRINKER. *Mech. Eng.*, **58** [3] 171–76 (1936).—Respirators are classified in detail, their general requirements are discussed, and many types are described. Illustrated. F.G.H.

CIRCULAR

Bureau of Mines apparatus for demonstrating electrical ignition of mine gas. E. J. GLEIM. *U. S. Bur. Mines Information Circ.*, No. 6944, 5 pp. Free. G. describes types of apparatus that can be used to demonstrate hazards of ignition of explosive gas by electrical equipment (1) in the Bureau of Mines Pittsburgh station and (2) in the field. R.A.H.

PATENTS

Apparatus for separating fine from larger particles by air flotation. FIRMA J. M. LEHMANN. Fr. 803,881, Oct. 10, 1936; *Chem. Abs.*, **31**, 2477 (1937).

Brick and stone drill. C. L. GAIROARD (Kraeuter & Co., Inc.). U. S. 2,088,197, July 27, 1937 (Oct. 7, 1936).

Ceramic articles. N. V. VOOR KERAMISCHE EN CHEMISCHE INDUSTRIE "KERO-CHEMICA." Ger. 636,254, Oct. 6, 1936; Cl. 80*a*. 49; *Chem. Abs.*, **31**, 828 (1937). The manufacture of ceramic articles, by uniting previously formed parts by means of a clay slip, is effected under the influence of short, rapid vibrations.

Ceramic masses. KERAMCHEMIE-BERGGARTEN G.M.B. H. (Fritz Gareis, inventor). Ger. 637,905, Nov. 6, 1936; Cl. 80*b*. 12.01; *Chem. Abs.*, **31**, 5530 (1937). A process for degassing and compressing ceramic masses by vacuum treatment and pressing is described.

Device for conveying articles in continuous furnaces. PIERRE BERTRAND (N. V. Mij. tot Beheer en Exploitatie van Octrooien). U. S. 2,088,284, July 27, 1937 (Oct. 14, 1936).

Electrical precipitation of suspended particles from gases. WHESSOE FOUNDRY & ENGINEERING CO., LTD., A. G. GRANT, AND A. PUTTICK. Brit. 467,823, July 7, 1937 (Dec. 19, 1935).

Forming die. C. J. RODMAN (Alliance Porcelain Products Co.). U. S. 2,087,302, July 20, 1937 (June 6, 1935).

Hammer mill. N. FREDRIKSSON (Aktiebolaget Åbjörn Andersson). Swed. 84,359, Sept. 9, 1935; *Chem. Abs.*, **31**, 2480 (1937).

Machine for propelling abrasives, etc. J. W. JACKMAN & CO., LTD., AND F. W. NEVILLE. Brit. 469,451, Aug. 5, 1937 (Jan. 23, 1936).

Material for making molds. I. G. FARBENIND. A.-G. Fr. 806,409, Dec. 16, 1936; *Chem. Abs.*, **31**, 4784 (1937). Molds, particularly for use in the dental art, are made from a ceramic substance or mixture of ceramic substances capable of hardening during firing, a substance composed of 1 or more compounds which enter into reaction with phosphoric ions to form a phosphate hardening at ordinary temperature, and a substance practically free of alkali which furnishes phosphoric ions in the presence of an aqueous solvent. Examples are given.

Means for degasifying clay and like plastic masses in extrusion presses. PAUKERWERK A.-G. VORM. ERNST BRÜNNER MASCHINEN-FABRIKS-GES. Austrian 146,897, Aug. 25, 1936; Cl. 80*b*; *Chem. Abs.*, **31**, 231 (1937).

Method and apparatus for shaping articles. B. A. JEFFERY (Champion Spark Plug Co.). U. S. 20,460, Aug. 3, 1937 (Feb. 8, 1937); reissue of original 1,863,854 (*Ceram. Abs.*, **11** [9] 499 (1932)). The method of forming a compressed shape from powdered or granular material comprises introducing the material between an interior rigid core and an elastic surrounding container of substantially the same internal shape, but of larger size, than the exterior of the desired article and compressing the container with the material therein by substantially uniform fluid pressure external to the container.

Plant for the artificial drying of ceramic products and in particular of tile and brick. J. B. MONNIER. U. S. 2,089,399, Aug. 10, 1937 (Jan. 7, 1936).

Kilns, Furnaces, Fuels, and Combustion

Combination burning of coal, oil, gas, and refuse. ANON. *Power*, **80** [9] 488 (1936).—Six types of combination burners, all designed to burn at least two fuels, are described and illustrated. F.G.H.

Elimination of sulfur from flue gases. ANON. *Ind. Chemist*, **12** [135] 157–62 (1936).—A modified method of eliminating sulfur from flue gases has been suggested due to conclusions from previous experimental work. The

process consists of subjecting the flue gases first to an alkaline spray and then an acid spray. Best washing conditions exist when the alkaline spray contains excess chalk and the acid spray has a p_H below 2.3. One important consideration in favor of the acid-ferric sulfate process is the fact that pure carbon dioxide is produced as a by-product in quantity equivalent to about half the chalk added. Illustrated by a diagram. H.E.S.

Fused silica in heating processes: II, Gas burners. BURROWS MOORE. *Ind. Chemist*, **12** [141] 451–53 (1936).—Two types of Vitreosil fuel burners have been developed. One consists simply of two concentric Vitreosil tubes, the outer one being connected to the fuel-gas source and the inner one to a source of compressed air. The other consists of a gas-jet tube with an orifice positioned within an envelope which, shaped on the Venturi principle, provides for mixing of the fuel gas and the air entrained through the air ports. For Part I see this issue, p. 297. H.E.S.

Gas fuel in the metal industry. D. CHANDLER. *Metal Ind.* [London], **48** [10] 295–99 (1936).—The methods for burning gas and the systems available for its control are considered. Its use in nonferrous metals melting, heat treatment of metals, atmosphere control, and temperature control are discussed. The use of carefully controlled gas firing in tunnel kilns for firing porcelain without muffles is also discussed. H.E.S.

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. Translated in *Brit. Clayworker*, **46** [543] 106–108 (1937).—A commentary on the operation of intermittent kilns is presented. See *Ceram. Abs.*, **16** [9] 284 (1937). R.A.H.

Most important terms in the construction of electric furnaces. W. FISCHER. *Elektrowärme*, **7** [6] 123–24 (1937).—Design and operating terms are compiled and defined. M.H.

Oil burners, types and characteristics. ANON. *Power*, **80** [9] 486–87 (1936).—Oil burners are classified according to the method of obtaining atomization of the oil: (1) mechanical, (2) steam or air, and (3) rotary cup. Typical examples of these types are described, and factors affecting their selection and arrangement are discussed. Illustrated. F.G.H.

Practical hints to prevent irregularities of firing. L. TONTSCHEFF. *Keram. Rundschau*, **45** [6] 59–61 (1937).—T. discusses different causes of irregularities, *e.g.*, kiln system and construction, distribution of ware, supervision, fuel, combustion, time schedule, control, and kiln condition. F.E.V.

Systems for burning pulverized coal. ANON. *Power*, **80** [9] 478–79 (1936).—The influence of the grindability and the ash, moisture, and volatile contents of the coal on the design and operation of a pulverized-coal system are discussed. Illustrated. F.G.H.

BOOK

How to Build Up Furnace Efficiency. J. W. HAYS. Dunes Publishing Co., Michigan City, Ind., 1936. 559 pp. Price $3.00. Reviewed in *Mech. Eng.*, **58** [7] 463 (1936).—Much practical information is given in this elementary manual on combustion engineering. F.G.H.

PATENTS

Electric resistance furnace. ADOLF HEINZ AND WIRTSCHAFTSVERBAND DER PORZELLANINDUSTRIELLEN. Ger. 632,669, July 11, 1936; Cl. 21*h*. 15.02; *Chem. Abs.*, **31**, 232 (1937). The furnace is used for ceramics and can attain temperatures of 1500 to 1600°.

Kiln. J. T. ROBSON AND G. R. SYLVESTER (Ferro Enamel Corp.). U. S. 2,088,554, July 27, 1937 (June 30, 1936).

Kiln for firing ceramic materials. FABRIQUE DE PORCELAIN LANGENTHAL, S. A. Fr. 800,716, July 17, 1936; *Chem. Abs.*, **31**, 232 (1937).

Geology

Aspects of clay chemistry. A. BRAMMALL AND J. G. C. LEECH. *Sci. Jour. Roy. Coll. Sci.*, **7**, 69–78 (1937); *Chem. Abs.*, **31**, 4926 (1937).

Catalytic decomposition of hydrogen peroxide by clay suspensions. N. F. ERMOLENKO, E. N. NOVIKOVA, AND V. YA. GUTERMAN. *Belaruskaya Akad. Navuk. Inst. Khim. Sbornik Prats.*, **1**, 113–30 (1934); *Chem. Abs.*, **31**, 2077 (1937).—The adsorption and catalytic activities of air-dried, calcined (at 120 to 700°), and water- and acid-activated clay suspensions of 0.25 to 0.5 mm. were studied. No strict relation between adsorption and catalytic effect was observed. Clays having a high adsorption value are very weak catalysts, while those of medium adsorption are good catalysts. Clays containing Fe_2O_3 act least upon H_2O_2. The catalytic activity falls with rise in temperature of calcination, especially above 400°.

Distribution of the world's mineral wealth. J. A. DUNN. *Trans. Mining & Geol. Inst. India*, **33** [1] 61–124 (1937).—A comprehensive statistical data compilation and a survey are presented. D. concludes that the English-speaking nations more or less hold the monopoly of strategic minerals and in combination could influence the course of a local or world disturbance of the peace. A.P.S.

Feldspar in Western Australia. E. N. GRIMWADE. *Australian Food*, **6** [12] 27 (1937).—Near Coolgardie, W. A., are deposits which have yielded 8000 tons per annum for several years, at a price of $7.68 per ton. These deposits have now been acquired by Australian Glass Manufacturers, Ltd., and an additional plant is being installed, the Australian market for feldspar being thereby controlled. H.H.S.

Granitic sands and clays; distribution and origin. H. DOUVILLÉ. *Bull. Soc. Géol. France*, **6**, 17–40 (1936); *Chem. Abs.*, **31**, 344 (1937).—D. gives a detailed description of the distribution, nature, and origin of these sands accompanied by several analyses. The kaolin suitable for porcelain and the refractory clays have been separated from the quartz sands by aqueous action. The Fe ores of Berry, closely associated with the sands, are thought to have had a common origin with them.

Hydrolysis of rock-forming minerals. A. BRAMMALL AND J. G. C. LEECH. *Nature*, **139** [3522] 754 (1937).—

The authors find that many rock-forming silicates yield alkali to cold water and several micas yield alumina on treatment with weak solutions of NaCl or KCl. Mineral dusts ground under benzene, bromoform, or methylene iodide are inert to water due to the formation of a protective film which may be dispelled by alcohol or by further grinding. The geological significance of these observations is suggested. J.L.G.

Important silicates of the district north of the peninsula of Lower California. Teodoro Flores. *Ingenieria* [Mexico], **10**, 5–11 (1936); *Chem. Abs.*, **31**, 3827 (1937).—In small valleys near the crest of the San Pedro Mártir mountains there occur deposits of garnet, tourmaline, and feldspar remarkable for perfection, size of crystals, and mode of deposition. Large garnet crystals, some almost perfect, were found in the Santa Rosa Valley. Analysis of the deepest red, transparent pieces showed SiO_2 36.15, TiO_2 0.12, Al_2O_3 19.78, Fe_2O_3 2.18, FeO 25.06, MnO 14.54, MgO 1.21, and CaO 0.87%. The mineralogical composition is pyrope 4.04, almandite 57.94, spessarite 33.92, and andradite 2.63%. Large, black, ferriferrous tourmalines (schorlite) are plentiful. Mica from the valley of San Ramón is of tabular habit and belongs to class 1 (plane of the optic axis $\perp$ (0.10)). The average K_2O content was 10.45%. Large reddish feldspar crystals also occur in the pegmatites. These have a somewhat pearly luster caused by a film of chlorite. Silicification is discussed. It is probable that the pegmatites are in some cases of igneous-aqueous origin modified by high temperatures and great pressures and in other cases were formed by molten igneous intrusion.

Mechanical analysis of lateritic soils: II, Note on the applicability of the hypobromite method. J. N. Chakraborty and A. T. Sen. *Indian Jour. Agr. Sci.*, **5**, 39–40 (1935).—The percentages of clay obtained by International-A and Troell's hypobromite methods have been compared in some of the Indian lateritic soils. It is shown that the dispersion of some of the Indian lateritic soils by the hypobromite method is not complete unless (1) sufficient NaOH is added to bring the p_H of the suspension to 10.5 and (2) the suspension is shaken for a longer time than that recommended in the original method. **III, New method using alkaline permanganate for oxidation of organic matter.** J. N. Chakraborty. *Ibid.*, pp. 41–50; see "Applicability—," *Ceram. Abs.*, **16** [4] 128 (1937). A.P.S.

Nature and relations of the zeolites; a review. Max H. Hey. *Trans. Ceram. Soc.*, **36** [3] 84–97 (1937).—The zeolite minerals are defined as being similar to the base-exchange clays except in composition, and a review of their structures, as far as they are known, is given. The zeolites are essentially replacement structures based on open meshed silicon-aluminum-oxygen anionic frameworks, the strength and stability of which are due to homopolar binding. Water molecules occupy definite lattice positions but are not firmly held and can be removed without breakdown of the structure; the equilibrium water-vapor pressure over a zeolite at any given temperature varies with the water content of the zeolite. Vapor-pressure or dehydration data show that for the removal of water an activation energy greater than the activation energy of migration of the water within the lattice is necessary and by simple kinetic treatment an equation can be developed which covers all possible types of vapor-pressure surface. The place of removed water can be taken by a variety of molecules provided they are small enough to enter the migration channels and the chemical affinity as measured by the activation energy of escape is adequate. The relation of the zeolites to other natural groups of compounds, such as the ultramarines and the permutites, is discussed. Clays, especially the montmorillonite-beidellite series, resemble the zeolites closely in their dehydration and base-exchange properties, but instead of the whole of the monovalent and divalent cations being exchangeable, only part react. The most striking difference is that only the clays can enter into base-exchange reactions involving hydrion. See "Studies—," *Ceram. Abs.*, **15** [5] 166 (1936).

R.H.H.P., Jr.

Synthetic clay minerals and porcelain from synthetic kaolin. W. Noll. *Sprechsaal*, **70** [10] 127–29; [11] 143–46 (1937).—Clay minerals are discussed according to composition and structure. Kaolins (ceramic clays) of the composition $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ and montmorillonite (fuller's earth and bentonite) of the composition $Al_2O_3 \cdot 4SiO_2 \cdot H_2O \cdot nH_2O$ were chiefly studied. Kaolin synthesis results from simple heating under pressure of hydrates of alumina and silica. The best conditions exist when temperatures from 300° to 350°C are used, the raw mixture is in the ratio of 1 to 2, and steam pressure is about 87 atmospheres. Pyrophyllite is formed if too high temperatures are used. When increased additions of alkalis or hydroxides of alkaline earth are added to the system Al_2O_3–$SiO_2 \cdot H_2O$ (with a ratio of 1 to 4) some montmorillonite is formed besides alkalis. Under certain optimum concentrations of hydroxides, montmorillonite alone is produced. The conditions of its formation are similar to those of synthetic kaolin. Kaolin synthesis does not depend only on alkali-free systems but can occur also in those containing alkalis. The synthetic minerals were studied by means of X-rays and dehydration curves. The particle size of synthetic kaolin is smaller; this fact becomes noticeable in dehydration tests. The chief differences, however, lie in the fact that synthetic kaolin is free from impurities (Fe_2O_3, TiO_2, and alkalis). X-ray pictures of synthetic montmorillonite are similar to those of natural montmorillonite. The intercrystal swelling of synthetic montmorillonite (increase in the angle of refraction of the 001 interference with lowered water content) and the change in the "layer interval" (001) with that of the steam pressure in natural and synthetic montmorillonite are discussed. Experiments of other investigators with regard to synthetic kaolin are outlined. It was found that an addition of Lothain kaolin to porcelain manufactured from synthetic kaolin (50% synthetic kaolin, 25% quartz sand, 25% feldspar) was necessary to increase plasticity. A crucible made from it was fired to cone 15; it remained white in spite of the addition. Shrinkage on drying amounted to 5% (linear) and shrinkage on firing, 10.5%. See "Mineral—," *Ceram. Abs.*, **15** [2] 72 (1936). M.V.C.

BOOKS AND BULLETINS

Barium Minerals. Anon. Imperial Inst., London. 84 pp. Price 2s net. This booklet gives an adequate review of the principal barium minerals, their preparation, uses, production, marketing, etc., and sources of barium minerals

in the British Empire and foreign countries together with comprehensive statistical matter. In view of the widespread utilization of barytes, the present book should prove useful. A.P.SOM

Distribution of clay by uses in 1935–36. ANON. *U. S. Bur. Mines Mineral-Market Rept.*, MMS 578. 6 pp. Free. An advance summary for the industry is given. R.A.H.

Feldspar industry makes new record in 1936. ANON. *U. S. Bur. Mines Mineral-Market Rept.*, MMS 573. 3 pp. Free. R.A.H.

Geologic factors in the interpretation of fluorspar reserves in the Illinois-Kentucky field. L. W. CURRIER. *U. S. Geol. Survey Bull.*, No. 886–*B*, 9 pp. Price 5¢ from Supt. of Documents, Govt. Printing Office, Washington, D.C. C. reviews the major geologic features of the field and includes a chart showing trends in the production, importation, and utilization of fluorspar. R.A.H.

Geology and mineral resources of the western part of the Arkansas coal field. T. A. HENDRICKS AND BRYAN PARKS. *U. S. Geol. Survey Bull.*, No. 847-*E*, 35 pp. Price 25¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. The exposed stratified rocks of the area belong to the Atoka, Hartshorne, McAlester, Savanna, and Boggy formations of Pennsylvanian age, and consist of alternating beds of shale and sandstone and associated coal beds. R.A.H.

Kaolin or china clay industry in 1936. ANON. *U. S. Bur. Mines Mineral-Market Rept.*, MMS 575. 2 pp. Free. An advance summary for this industry is given. R.A.H.

Minerals Yearbook, 1937. U. S. BUREAU OF MINES. 1500 pp. Supt. of Documents, Govt. Printing Office, Washington, D. C. Price $2.25. The book reviews the mineral industry during the calendar year 1936, both in the U. S. and abroad; contairs official Government statistical information on nearly 100 metals, minerals, and mineral products; and presents a comprehensive and accurate record of economic developments and trends in mining. It is of current interest and lasting value, both to the mining industry and the general public, and is indispensable to everyone interested in domestic and international trade in minerals. In addition to presenting detailed commodity statistics, the volume reviews the status of mining in relation to American industry. Efforts of foreign powers to attain self-sufficiency in strategic materials are described. Progress in mine mechanization is brought up to date through the results of a coöperative study with the National Research Project of the WPA. Detailed data heretofore released through the Statistical Appendix, publication of which has been discontinued, is included. R.A.H.

Pyrochemical changes in Missouri halloysite. FRANK J. ZVANUT, LYMAN J. WOOD, C. M. DODD, AND W. T. SCHRENK. *School Mines & Met., Univ. Missouri, Bull.*, 12 [3] 42 pp. (March, 1937); see *Jour. Amer. Ceram. Soc.*, 20 [8] 251–57 (1937). F.J.Z.

Vermiculite, a new commercial mineral. ANON. *U. S. Bur. Mines Mineral-Market Rept.*, MMS 549. 2 pp. Free. R.A.H.

Chemistry and Physics

Adsorption on measured surfaces of vitreous silica: II. W. G. PALMER. *Proc. Roy. Soc.* [London], **A160**, 254–67(1937).—Earlier work on the adsorption of vapors on known surfaces of vitreous silica has been extended by measurements up to saturation pressures with benzene, acetone, and methyl alcohol. The S-shaped form of the isothermals is discussed, and reasons are advanced for attributing all of the condensation to pure adsorption. The films are four molecules thick at saturation, but the linear relation between the log of the adsorption potential and the amount adsorbed holds strictly over almost the whole pressure range. The spreading forces calculated from observations agree with those calculated from certain equations of state for the films. The observed maximum value of the adsorption potential can be accounted for on the basis of dipole interaction between the surface and the adsorbed molecules. Comparisons are made between the behavior of films of small molecules on the solid and that of films of long-chain molecules on water. For Part I see *Ceram. Abs.*, 16 [5] 160 (1937). A.P.

Applications of floating equilibrium to determination of density. H. IRVING. *Science Progress*, 31 [124] 654–65 (1937).—I. describes the more important methods based on the principle used by Archimedes when he determined the gold in the crown of Hiero. Reference is given to Andreae's modification of Retger. H.H.S.

Chemical studies of silicates: IV, Behavior of pyrophyllite, $Al_2(Si_4O_{10})(OH)_2$, on heating and the existence of a "water-free pyrophyllite," $Al_2(Si_4O_{10})O$. ERICH THILO AND HEINZ SCHUNEMANN. *Z. Anorg. Allgem. Chem.*, 230 [4] 321–35 (1937).—Pyrophyllite loses water at about 400° C. The rate of loss and the maximum amount evolved depend on the fineness of the sample. The dehydrated pyrophyllite does not reabsorb water at low vapor pressures but does pick it up from the air. The solubility of pyrophyllite in NaOH and in HCl is constant in samples heated up to 400°. On gradual heating up to 1100° there is an increase in the solubility. Above 1100° the solubility becomes very great. The changes in solubility are attributed to a change in the lattice. X-rays show that pyrophyllite changes into a new crystal form on losing water at 400° but without passing through an intermediate amorphous state. The X-ray pattern of the water-free pyrophyllite is practically identical with that of talc. Water-free pyrophyllite to which the formula $Al_2(Si_4O_{10})O$ is assigned is stable up to 1150°. Above this temperature the lattice breaks down and mullite and cristobalite form from the components. **V, Nature of the reaction products of pyrophyllite with molten $MgCl_2$ and $CoCl_2$.** *Ibid.*, pp. 375–80.—The nature of the reaction products of these materials was studied by means of X-rays. At 800°C reaction takes place. With $MgCl_2$, pyrophyllite forms cordierite ($MgO \cdot Al_2O_3 \cdot 2.5SiO_2$) and free silica; with $CoCl_2$, it forms silica and cobalt spinel. For Part III see *Ceram. Abs.*, 15 [4] 133 (1936). L.T.B.

Chemistry and analysis of beryllium (glucinum). LUCY F. KERLEY. *Jour. Australian Chem. Inst.*, 4 [6] 223–32 (1937).—Be may be separated from Al and Fe by the bicarbonate or 8-hydroxyquinoline methods. Precautions that should be taken are described. H.H.S.

Crystallization of zinc borate. R. PARIS AND P. MONDAIN-MONVAL. *Compt. Rend.*, **202** [25] 2075–77 (1936).—The crystallization conditions of vitreous zinc borate were investigated. Crystallization begins at about 520°C, reaches a maximum at 820°, and is at 0 again at about 970°C. 5 references. M.H.

Decomposition of ferrous oxide. J. BÉNARD AND G. CHAUDRON. *Compt. Rend.*, **202** [15] 1336–38 (1936).—The disintegration products of FeO were investigated thermomagnetically. While at temperatures above 570°C the decomposition takes place according to $4FeO \rightarrow Fe + Fe_3O_4$, at lower temperatures a reaction of the form $8FeO \rightarrow Fe_3O_4$ + solid solution (Fe + 4 FeO) takes place. M.H.

Determination of alumina by *o*-oxyquinoline. P. P. BUDNIKOV AND S. S. ZHUKOVSKAYA. *Zhur. Priklad. Khim.*, **9** [11] 2079–87 (1936). P.B. & E.S.

Diffraction of electrons by quartz glass. N. A. SHISHAKOV. *Zhur. Tekh. Fiz.*, **5**, 1834–41 (1935); *Chem. Abs.*, **31**, 29 (1937).—A drop of a suspension in water of finely powdered quartz glass was set on a celluloid film from which the structure of the quartz glass was studied by electronic diffraction. The quartz glass was found not to be amorphous but to consist of crystals of tetragonal cristobalite, apparently the size of colloidal particles. See *Ceram. Abs.*, **15** [2] 58 (1936).

Dissolution of silica in potassium or sodium silicates. S. K. CHIRKOV, A. I. KINJAK, AND E. V. LOBANOV. *Zhur. Khim. Prom.*, **13**, 1300–1305 (1936).—The dissolution velocities in potassium silicates are higher than in sodium silicates. In the case of metasilicates, the reaction velocity is higher than in that of disilicates. With the increase of the SiO_2 content in both potassium and sodium silicates, the dissolution velocity of silica falls. The dissolution velocity of SiO_2 in silicate mixtures depends on the temperature, the composition of the mixture, and the silica content. When dissolving SiO_2 in mixtures of potassium and sodium metasilicates, the isotherms of lnK in dependence of the composition disclose a maximum lying over lnK for pure components and which displaces to the side of potassium metasilicate with the increase of temperature. In the case of disilicates there is a maximum and a minimum. Under 1000° the former lies between lnK for pure disilicates and increases with the increase of temperature. The minimum obviously corresponds with a chemical combination of the disilicate mixture components, the maximum with the eutectic of the mixture. When preparing mixed soluble glass, it is advantageous to use eutectic disilicate mixtures. A chemical combination in the system $K_2O{\cdot}2SiO_2$–$Na_2O{\cdot}2SiO_2$ will have a noxious effect on the process of obtaining soluble glass, lowering the rate of its formation, on the ready product, lowering the rate of its dissolution in water, and the silicate modulus of dissolved glass. Potassium silicates lixiviate water easier than sodium silicates. The data obtained can be used for technological calculation of the process of production of soluble glass from potassium and sodium chlorides. P.B. & E.S.

"Dithizone" an excellent reagent for lead. C. F. MILLER. *Chemist-Analyst*, **26** [3] 55 (1937).—A 0.01% solution of diphenylthiocarbazone in carbon tetrachloride or carbon disulfide yields bright red flakes at the interface when shaken with an ammoniacal potassium cyanide solution that distinguishes minute quantities of lead even in the presence of fairly large quantities of Ag, Cu, Ni, Zn, Cd, Sb, Bi, and As. Tin, thallium, and very large quantities of bismuth and cadmium interfere. Preparation of the reagent is described. A.P.

Heat content of the various crystalline modifications of zinc hydroxide. R. FRICKE AND K. MEYRING. *Z. Anorg. Allgem. Chem.*, **230** [4] 357–65 (1937).—The differences in the molar heat content of four crystalline modifications of zinc hydroxide and of the pseudoamorphous zinc hydroxide were measured. The heat contents of the crystalline modifications are very close; the three unstable forms show differences of not more than about 100 cal. The most stable hydroxide has a heat content about 200 cal. lower than the next stable form. L.T.B.

Innovations in the technique of microscopy in the service of the ceramic industry. KARSTEN. *Céram., Verreric, Émail.*, **4** [10] 389–93 (1936).—Progress in the construction of microscopes and photographic microscopes has made possible rapid observation in reflected light, oblique light, transmitted and polarized light, and fluorescent light. Examination with polarized light is important in the glass industry to determine tensions. Transmitted light shows the crystalline character of glass, and other defects can be determined microscopically. Modern types of photographic microscopes are described. M.V.C.

Layer lattice in relation to mineral chemistry. ALFRED BRAMMALL AND J. G. C. LEECH. *Science Progress*, **31** [124] 641–53 (1937).—The structure and variable composition of the clay species, micas, and chlorites was interpreted by L. Pauling (1930) by his layer-lattice conception, founded on the application of X-rays to the study of crystals. Thus the silicate minerals, formerly in detached species and groups, are being welded into communities of a small number of structural types. The kaolinite-halloysite group is especially discussed. Lattice shrinkage during dehydration of bentonites is attributed to a distinction between mechanically held and fixed water; the general formula of the montmorillonite-beidellite group is $NH_2O{\cdot}(OH)_4{\cdot}Al_4(Si_8O_{20})$. Base-exchange between clays is discussed. H.H.S.

Measuring heat of hydration. F. M. LEA. International Assn. for Testing Materials, London Congress, April, 1937. *Concrete* [Cement Mill Ed.], **45**, 173–74 (1937). W.D.F.

Mechanism of the phenomenon of the exchange of bases. G. AUSTERWEIL. *Bull. Soc. Chim.*, [5] **3**, 1782–90 (1936); *Chem. Abs.*, **31**, 306 (1937).—Glauconite was triturated with solutions of $CaCl_2$, the solution was renewed until it was saturated, washed until there was no more chloride in the wash water, and dried to constant weight at 102 to 105°. An aliquot part of the glauconite was placed in contact with aqueous $MgCl_2$ solution of equivalent concentration. After mixing, the solid was found to have taken up 80% of the Mg. The glauconite was then removed from the liquid and washed thoroughly. The wash water was added to the solution and the mixture concentrated to the original concentration of the $MgCl_2$ solution. This was put in contact with a new aliquot of the glauconite treated with $CaCl_2$ and the procedure repeated. It was found that 80% of the Mg ions remaining in solution were taken up again, indicating that base ex-

change takes place according to the law of extraction. These figures are checked by treating the glauconite with NaCl and determining the Ca and Mg going into solution. The Mg was found to be distributed between the glauconite and the solution according to the distribution law in proportion to their respective solubilities (4:1). This confirms the conclusion from previous work (*Ceram. Abs.*, **15** [11] 345 (1936)) that base exchange is regulated by the laws of extraction, the solid taking the part of a non-miscible liquid. A correlation was found between the extraction formula and the empirical adsorption equation, shown to govern the base exchange between constituents of the soil and aqueous solutions of cations.

Melting point diagrams of refractory oxides: VII, Systems with CaO and BeO. H. VON WARTENBERG, H. J. REUSCH, AND E. SARAN. *Z. Anorg. Allgem. Chem.*, **230** [3] 257–76 (1937).—Melting point diagrams were plotted from the observations of the softening point and the formation of drops on 2 mm. rods of the mixtures of the oxides in a gas-fired furnace. The tube of the furnace was made of ZrO_2. Temperatures were measured with a micropyrometer with the aid of a steel mirror beneath the furnace. Temperatures up to 2900°C were recorded. The following oxide systems were studied: CaO with Cu_2O, BeO, SrO, BaO, MgO, Al_2O_3, TiO_2, SiO_2, ZrO_2, ThO_2, PbO, Fe_2O_3, Mn_3O_4, NiO, CoO, and Cr_2O_3; and BeO with Cu_2O, MgO, La_2O_3, CeO_2, TiO_2, ThO_2, Cr_2O_3, Mn_3O_4, Fe_3O_4, CoO, and NiO. For Parts **V–VI** see *Ceram. Abs.*, **12** [2] 63 (1933). L.T.B.

Precision determinations of the lattice constant of quartz and new measurements of the Kα wave-length of the elements 45Rh, 46Pd, and 47Ag. SVEN ELG. *Z. Physik*, **106** [5] 315–21 (1937).—The lattice constant of quartz (plane 0001) was determined accurately for the first three orders with Mo Kα. Kα_2 and Kα_1 of the three elements were measured in the first two orders. The index of quartz for those wave-lengths was evaluated. L.T.B.

Products of interaction of sodium silicates with electrolytes: I. V. A. KARGIN, S. A. KATZ, AND A. F. KOMOVSKIĬ. *Zhur. Priklad. Khim.*, **10** [1] 82–85 (1937).—X-ray investigations and investigation of strength in dependence on the viscosity of initial solutions of soluble glass with an addition of bivalent electrolytes showed that the action of bivalent electrolytes on soluble glass solutions forms no silicates. All gels obtained had a cristobalite structure. **II.** V. A. KARGIN AND S. A. KATZ. *Ibid.*, pp. 86–92.—The adsorbing power of SiO_2 gels in relation to CaO and the effect of the properties of the initial solutions on the adsorptive power of SiO_2 gels were investigated. It is suggested that the differences of adsorptive power observed depend on the amount of crystalline silica formed in the initial soluble glass solution. P.B. & E.S.

Reactions caused by "activated" alumina. R. S. CAHN AND R. F. PHIPERS. *Nature*, **139** [3521] 717–18 (1937).—The authors report that commercially activated aluminas contain relatively large amounts of alkali, as much as 0.41% calculated as NaOH, and can bring about in neutral solvents reactions which are normally associated with alkaline reagents in hydroxylic solvents. This may be responsible for abnormal results recorded by other workers. J.L.G.

Reactions in the solid state: I, Development of our knowledge of the reactivity of the solid state. J. A. HEDVALL. *Angew. Chem.*, **49**, 875–79 (1936); *Chem. Abs.*, **31**, 598 (1937).—A discussion of the available literature is given. 51 references. **II, Course of reactions in the solid state.** WILHELM JANDER. *Angew. Chem.*, **49**, 879–82 (1936).—J. gives a summary of the present-day knowledge. 23 references. **III, Active states which must occur in reactions which involve several solid substances.** GUSTAV F. HÜTTIG. *Ibid.*, pp. 882–[illegible]2.—The following subjects are treated: (1) changes of the properties of a powdered mixture in the course of its gradual heating, (2) division of the over-all reaction into individual steps and their meaning, (3) systems which have been examined and their comparison, and (4) various effects that can change the course of the reaction. 81 references. **IV, Reactions in the solid state in the silicate industry.** W. EITEL. *Ibid.*, pp. 895–901; *Chem. Abs.*, **31**, 1172 (1937).—E. discusses the problem in connection with the ceramic, cement, glass, and enamel industries. 86 references.

Silicate science. G. W. MOREY. *Jour. Amer. Ceram. Soc.*, **20** [9] 283–87 (1937).

Sintered magnesite: I, Quantitative investigation of the compounds produced. KAMILLO KONOPICKY AND HANS KASSEL. *Ber. Deut. Keram. Ges.*, **17** [10] 465–83 (1936).—The following points were investigated: the behavior of iron oxide and magnesite, the effect of silica, the effect of CaO, and the reactions between CaO and silica. Mixtures of the most varied composition were prepared from the four components MgO, Fe_2O_3, SiO_2, and CaO. The analyses of the residues after treatment with 10% NH_4NO_3 solution were compared with the analyses of the original sinter. When lime is absent, only MgO goes into solution on treatment with NH_4NO_3 solution. The residue corresponds to a mixture of magnesium orthosilicate and magnesium ferrite. In the presence of lime, the magnesia, most of the lime, and part of the silica go into solution, again leaving a residue consisting of a mixture of magnesium orthosilicate and magnesium ferrite. With lime but little or no silica present, dicalcium ferrite or its reaction products with magnesia are present. With increasing silica content, the quantity of calcium magnesium ferrite formed becomes less and less, disappearing when the lime-silica ratio of about 1 is reached. As long as the calcium ferrite reaction is taking place, part of the silica is present as dicalcium silicate. On the disappearance of calcium magnesium ferrite (due to excess of SiO_2), monticellite occurs instead of dicalcium silicate. Even with finely divided mixtures of MgO and Fe_2O_3 and CaO, the reaction is not complete after heating for one hour at 1500°, excess free lime always remaining behind. Investigations on three different sintered magnesites proved the practicability of this method of testing, as the results were in agreement with microscopic examinations of thin sections. E.J.V.

Sodium hypo-iodate a specific reagent for magnesium. MARIAN CHAMBERS. *Chemist-Analyst*, **26** [3] 66 (1937).—The test solution is concentrated and a few cubic centimeters of fresh hypo-iodate solution is added. A brick-red to brown precipitate indicates magnesium. To prepare the reagent, add just enough caustic to a saturated solution of iodine in potassium iodide to decolorize the

iodine. The sensitivity is only 1 part per hundred thousand, but only large amounts of ammonium salts and aluminum interfere. A.P.

Spectroscopy in industry. A. FOWLER. *Jour. Sci. Instruments*, **14** [5] 153–61 (1937).—F. discusses the present and the possible positions of spectroscopic analysis, both qualitative and quantitative. Subjects considered are qualitative analysis, persistent lines, quantitative analysis, estimation of intensities, difficulties, some applications, and possible future developments. At present, spectroscopy's chief value to industry lies in the rapid determination of the minor constituents of materials. J.L.G.

Studies on active zinc oxide as well as the stability of zinc hydroxides. R. FRICKE AND K. MEYRING. *Z. Anorg. Allgem. Chem.*, **230** [4] 366–74 (1937).—Active and inactive zinc oxide were prepared from the crystalline and amorphous zinc hydroxides. The methods of preparation are described. The heat content of the active oxide depends on the method of preparation and also on the original material. The heat content of the active oxide decreases on continued heating at 100°C. The changes in the heats of solution are discussed from the standpoint of changes in the lattice as detected by X-rays. See "Thermal and X-ray—," *Ceram. Abs.*, **14** [1] 23 (1935). L.T.B.

Use of fluorides in the iodine titration method for copper in the presence of iron. MORRIS LIPSCHUETZ. *Chemist-Analyst*, **26** [3] 57 (1937).—Addition of 1 g. of alkali fluoride eliminates the need for separating ferric iron before the iodometric determination of copper. A.P.

Uses and limitations of X-ray diffraction methods. JOHN T. NORTON. *Jour. Applied Physics*, **8** [5] 307–13 (1937).—N. analyzes the usefulness of X-ray diffraction equipment as an industrial tool. He emphasizes the need for intelligent direction by someone who understands the nature of the information to be gained and has the ability to resolve the problems into their fundamental aspects. Basic types of information which may be obtained include (1) type and size of crystal lattice, (2) crystal orientation, (3) grain size, and (4) crystal distortion. A.P.

BOOKS AND REPORTS

Atlas of the spectra analysis lines of the most important elements (Atlas der analysen-linien der wichtigsten elemente). F. LOEWE. Theodor Steinkopff, Leipzig, 1936. 2d ed. 37 pp., 16 plates. Price 10 Rm. Reviewed in *Proc. Phys. Soc.* [London], **49** [4] 431 (1937).—This edition contains plates of selected regions of line spectra of 46 elements, a brief explanation and lists of wave-length, and data for another 11 elements not contained in the plates. A 10-page table gives analysis lines between λ 1854 and λ 8944. L.E.T.

Calculation of the specific heats and entropies of metal vapors from spectroscopic data, with special reference to gaseous iron and copper. K. K. KELLEY. *U. S. Bur. Mines Repts. Investigation*, No. 3341. 18 pp. Free. R.A.H.

Chloride volatilization of lithium from spodumene. FOSTER FRAAS AND OLIVER C. RALSTON. *U. S. Bur. Mines Repts. Investigation*, No. 3344. 11 pp. Free. The need for cheaper lithium salts for air conditioning, dehumidification, and for lithium feldspar to be used in glass and ceramic trades prompted the work of making available lower-grade spodumene deposits by improved beneficiation and extraction. R.A.H.

Graphs, How to Make and Use Them. H. ARKIN AND R. R. COLTON. Harper and Bros., New York, 1936. 224 pp. Price $3.00. Reviewed in *Mech. Eng.*, **58** [5] 329 (1936).—An excellent introduction to the subject is presented, the directions being unusually clear and simple. All the usual methods of graphic representation are covered and a wide variety of uses, including technical applications, are illustrated. F.G.H.

Statistical Methods for Research Workers. R. A. FISHER. Revised and enlarged. 6th ed. xiv + 339 pages. Oliver and Boyd, Edinburgh and London, 1936. Price 15s net. Briefly reviewed in *Nature*, **139** [3522] 737 (1937).—This is a standard work on this subject for the scientific worker. J.L.G.

Thermodynamics, the Principles of Thermodynamics and Their Application to Engineering Processes. L. C. LICHTY. McGraw-Hill Book Co., New York, 1936. 281 pp. Price $3.00. Reviewed in *Mech. Eng.*, **58** [10] 671 (1936).—L.'s aim was to simplify the treatment, strip it of many unnecessary mathematical manipulations, and consolidate it into logical groupings from the viewpoint of thermodynamic analysis rather than mechanical equipment. He also attempts a better balance than is usual between vapor and combustion processes. F.G.H.

PATENTS

Manufacture of metal silicates. W. A. SMITH. U. S. 2,088,281, July 27, 1937 (July 30, 1932). In the method of precipitating an insoluble metallic silicate from a relatively dilute solution of an alkali metal silicate, by a solution of a salt of another metal in which the amount of the other metal is at least approximately sufficient to effect complete substitution of the alkali metal, that improvement pertaining to the control of the reactivity of the insoluble metallic silicate which comprises maintaining the mixture while the precipitate forms, separating the precipitate from the solution, and drying the precipitate at a speed which is higher when a high chemical reactivity of the precipitate is desired and less when lesser chemical reactivity is desired.

Method of making boric acid. ALFRED NEWMAN (Pacific Coast Borax Co.). U. S. 2,089,406, Aug. 10, 1937 (Aug. 13, 1928).

Production of titanium dioxide. L'R. G. BOUSQUET, H. W. RICHTER, AND B. W. ALLAN (American Zirconium Corp.). U. S. 2,089,180, Aug. 10, 1937 (Feb. 11, 1935).

Silicates. PENNSYLVANIA SALT MFG. CO. Fr. 806,257, Dec. 11, 1936; *Chem. Abs.*, **31**, 4461 (1937).—A solid alkali subsilicate is made by mixing powdered SiO_2 and solid caustic alkali in proportions such that the content of the mixture in alkali oxide, *e.g.*, Na_2O, is not below its content in SiO_2, and in the presence of less water than will dissolve the NaOH. The mixture is heated to below the freezing point of the caustic alkali, *e.g.*, 175 to 450°.

Treatment of glass, glazes, and enamels. DEUTSCHE TAFELGLAS A.-G. (Detag) (Rudolf Geppert and Adolf Dietzel, inventors). Ger. 644,097, April 23, 1937; Cl. 32*b*. 6.50; *Chem. Abs.*, **31**, 5529 (1937).—The resistance of glass, glazes, and enamels to chemical influences is increased by treating the fused materials with steam

under such conditions that the finished products retain more than the usual proportion of water. Thus, a material which evolves water may be added to the melt while an atmosphere of high steam content is maintained above the melt.

General

Ceramic filter media and high rates of filtration. M. LEVINE, R. LUBBERS, W. E. GALLIGAN, AND R. VAUGHN. *Sewage Works Jour.*, **8**, 701–27 (1936); *Chem. Abs.*, **31**, 1130 (1937).—Trickling filters employing 1 to 3 in. granite, ceramic Raschig rings (¾, 1, 1½, and 2¼ in. in diameter), and Straight's perforated blocks were studied at rates from 2 to 16 million gal./day. The ¾ and 1 in. rings gave the best removal of B. O. D. and nitrification, and the 1½ to 2¼ in. rings compared favorably with granite. B. O. D. reductions by the filters containing granite, perforated blocks, and 1 in. rings at 16 million gal./day loadings were 43.4, 48.8, and 49.4%, respectively. After sedimentation of the filter effluents, the B. O. D. removals were 78.6, 81.8, and 89.4%. The high reductions by sedimentation are attributed to the colloidal action of the filter, the coagulated organic matter being flushed out of the filter by the washing action of the high rate of dosage. The B. O. D. removal per acre ft. by filtration and settling increased from 450 to 3950 lb. with the granite filters and from 469 to 4500 lb. with the Raschig rings, when the rates of dosing were increased from 2 to 16 million gal. per day. The quality of the final effluents was reduced at these high rates.

Characteristic properties of certain industrial dusts. H. V. A. BRISCOE, P. F. HOLT, J. W. MATHEWS, AND P. M. SANDERSON. *Nature*, **139** [3522] 753–54 (1937).—The solubility in water of various dusts known to produce silicosis (crushed calcined flint, asbestos, feldspar, and pottery dusts) is a complex phenomenon depending on temperature, time, particle size, quantity, and on the presence of adsorbed films. Feldspar ground under benzene is not soluble in water but yields alkali in 95% alcohol. This must be due to an adsorbed benzene film. Silica dusts may have their solubility greatly reduced by mixing with an equal amount of powdered sugar charcoal, anthracite, or bituminous coal. Such additions have no effect on the quantity of soluble silica liberated from asbestos though they materially reduce the quantity of alkali liberated. The presence of Na_2CO_3 in water materially increases the yield of soluble silica from quartz dust. Extraction of asbestos dust with dilute acid does not cut down the yield of soluble silica. The presence of $Ca(OH)_2$ (but not $CaCO_3$) in small proportion inhibits the release of soluble silica from both quartz and asbestos. Granite wet-drilled in a Cornish mine gave values from 8 to 9% of water while the corresponding figure for the granite crushed dry was 0.6%. The authors conclude that freshly fractured surfaces of silica and some mineral silicates are in a highly reactive state and readily yield both alkali and soluble silica on contact with water. Thus the dusts may reach the workers lungs in a partially hydrated or dissolved state. They find that fine dusts aggregated by settling are much less reactive than when first formed. This may explain the failure of attempts to induce silicosis in animals by exposure to artificially raised dust clouds.

J.L.G.

Chemical and metallurgical industries in India. E. SPENCER. *Ind. Chemist*, **12** [137] 254–56 (1936).—In the Indian cement industry, consumption is now about on a par with production capacity. A large factory with a capacity of 100,000 tons per year was recently completed in southern India, and another factory is nearing completion 250 miles from Calcutta near the Karanpura coal field. A cement works being constructed in Burma proposes to utilize natural gas and oil instead of coal as a fuel. The yearly per capita consumption in India is 4 lb., while in the United Kingdom it is 230 lb. and in America 560 lb. Most of the glass used in India is imported from Japan. A few factories are in existence in the neighborhood of Calcutta, with a total daily production of about 20 tons of the cheaper qualities of glass articles, and several larger factories are situated in the Punjab and United Provinces near supplies of glass, sand, and feldspar. The absence of cheap indigenous soda ash is a very serious handicap to the development of this industry. H.E.S.

Dust. E. SMOLCZYK. *Gasmaske*, **8**, 16–19 (1936); *Chem. Abs.*, **31**, 2312 (1937).—S. gives a brief but excellent review of the dust problem. Among the points discussed are the sources of dust, the amount of dust in various locations, the loss of valuable products in the form of dust, the properties of dust particles, the physiological damage caused by dust, the body mechanism to protect against dust, and diseases due to dust.

"Kemite," a new ceramic laboratory table top material. S. M. PHELPS AND E. E. MARBAKER. *Crucible*, **21**, 136–37 (1937); see "Ceramic—," *Ceram. Abs.*, **16** [7] 225 (1937). W.D.F.

Laboratory, factory, and market. JORDAN A. PUGH. *Bull. Amer. Ceram. Soc.*, **16** [8] 350 (1937).

National Bureau of Standards. LYMAN J. BRIGGS. *Jour. Applied Physics*, **8** [5] 298–307 (1937).—The origin, functions, laboratory facilities, and present work of the Bureau are described. An organization chart for the research, testing, and commercial standardization divisions is included. A.P.

Nature of silicosis: I. ANON. *Concrete* [Cement Mill Ed.], **45**, 171–72 (1937).—Reports of the First National Silicosis Conference, 1936, and the Second National Silicosis Conference, 1937, are given. See *Ceram. Abs.*, **16** [1] 49 (1937). W.D.F.

BOOKS

Glass Factory Year Book and Directory, 1935. ANON. American Glass Review, Pittsburgh. 159 pp. Price $3.00. Reviewed in *Mech. Eng.*, **57** [8] 526 (1935).—The directory lists the American manufacturers of glass and glassware and the trade and workmen's associations and gives statistics on production and consumption. A buyers' guide to materials and equipment is also included. The information about factories includes the names of officers, equipment, and products. F.G.H.

Hutchinson's Technical and Scientific Encyclopedia.

Edited by C. F. Tweney and I. P. Shirshov. The Macmillan Co., New York, 1936. 4 vols. 2468 pp. Price $25.00. Reviewed in *Mech. Eng.*, **58** [7] 463 (1936). —This work is an intelligent attempt to meet the need of students and technical workers for quick reference on a great variety of subjects. See *Ceram. Abs.*, **15** [6] 193 (1936). F.G.H.

Kempe's Engineers' Year-Book, 1936. 42nd annual ed. Revised under direction of L. St. L. Pendred. Morgan Brothers, Ltd., London. 2664 pp. Price 31s 6d. Reviewed in *Power*, **80** [4] 219 (1936).—Articles on heat insulation, refractories, and cements are included in this volume. F.G.H.

Technology and the Mineral Industries. F. G. Tryon, K. C. Heald, T. T. Read, G. S. Rice, and Oliver Bowles. Works Progress Administration, Washington, D. C. 63 pp. Free. This report is the first in the series of "Mineral Technology and Output-per-Man Studies" conducted under a coöperative arrangement between the National Research Project of the Works Progress Administration and the Bureau of Mines. It is intended to serve as an introduction to forthcoming reports which will deal with the principal technological changes in the various extractive industries and the effect of these changes on the output per man. Chapter headings include: "Double task of mineral technology," "Technique of exploration," "Technology in coal mining," "Petroleum and natural gas," "Nonmetallic materials," "Major metals," "Lesser mineral industries," "Technology and mine safety," and "Social effects of pending technologic change." R.A.H.

PATENTS

Concretes with fired clay particles as an aggregate. H. Schwartzkopff. Brit. 465,318, May 20, 1937 (May 24, 1935).

Manufacture of ceramic products. A. D'Antoni and P. Cecchetti. Brit. 465,154, May 13, 1937 (Oct. 28, 1935).

Method of preventing efflorescence on the surface of colored roofing granules. Paul Teetor (Central Commercial Co.). U. S. 2,081,609, May 25, 1937 (Dec. 4, 1934). A method of treating granules suitable for use on roofing material comprises mixing barium carbonate, color pigment, and a binder containing frit, mixing the mass with granules, fusing the binder on the granules, and agitating the mass to prevent agglomeration.

Soldering of ceramic materials. Siemens & Halske Akt.-Ges. Brit. 466,049, June 2, 1937 (March 9, 1935).

HENRY LECHATELIER: II, HIS PUBLICATIONS*

By Alexander Silverman

NOTE: Co-authors precede a reference in parentheses. Abbreviations indicated in *Chemical Abstracts*, wherever possible, are employed in Journal references.

Manganese and phosphorus and their use in manufacture of fine-grained cast iron, *Ann. mines*, [7] **6**, 216 (1874).
Dialysis of sodium silicoaluminate, *Compt. rend.*, **78**, 1046 (1874).
Origin of fibers in puddled iron, *ibid.*, **82**, 1057 (1876).
The interior sea, *Rev. Sci.*, **6**, 655 (1877).
Salts from Algerian "chott," *Compt. rend.*, **84**, 390 (1877).
Analysis of rocks from the Sahara, *Rev. géol.*, (1877).
Composition of ashes of some Saharan vegetation, *Jour. société d'agriculture* (1878).
Procedure for exact measurements of variations in height of a liquid surface, *Compt. rend.*, **87**, 1024 (1878).
(Mallard) Determination of marsh gas in loose coal, *ibid.*, **88**, 749 (1879).
(Mallard) Works of Prussian Commission on Firedamp, *Ann. mines*, [7] **18**, 193 (1879).
(Mallard) Experimental researches on safety lamps (supplement to Proceedings of Commission on Firedamp). 1° fascicule. Dunod, Paris (1880). 54 pp.
(Mallard) Temperatures of flammation of gas mixtures, *Compt. rend.*, **91**, 825 (1880).
Crystallized barium silicate obtained by M. Pisani, *ibid.*, **92**, 972 (1881).
(Mallard) Speed of cooling of gases at elevated temperatures, *ibid.*, **93**, 962 (1881).
(Mallard) Speed of propagation of flammation in explosive gas mixtures, *ibid.*, p. 145.
(Mallard) Specific heat of gases at high temperatures, *ibid.*, p. 1014.
(Mallard) Temperature of combustion and dissociation of carbon dioxide and water-vapor, *ibid.*, p. 1076.
Influence of barometric variations on escape of firedamp from coal mines (supplement to Proceedings of Commission on Firedamp). 1° fascicule. Dunod, Paris (1881). 98 pp.
(Mallard) Influence of annealing on resistance of lamp glass (supplement to Proceedings of Commission on Firedamp). 2° fascicule. Dunod, Paris (1881). 67 pp.
Formation of barium silicate, *Compt. rend.*, **92**, 931 (1881).
New anemometric apparatus (supplement to Proceedings of Commission on Firedamp). 2° fascicule. Dunod, Paris (1881). 104 pp.
(Mallard) Proper method of detecting firedamp in mines, *Ann. mines*, [7] **19**, 186 (1881).
Constitution of cements and theory of their hardening, *Compt. rend.*, **94**, 867 (1882).
(Mallard) Rôle of powdered coal in mine accidents, *Ann. mines*, [8] **1**, 5 (1882).
(Mallard) Work of Commission on Firedamp, *ibid.*, p. 153.
(Mallard) Researches on combustion of explosive gas mixtures, *Ann. mines*, [8] **4**, 272 (1882); *Bull. soc. chim.*, **39**, 2, 98, 268, 369, 572 (1882); *Jour. phys.*, [2] **1**, 173 (1882).
(Mallard) Vibratory motions in gas combustion, *Compt. rend.*, **95**, 599 (1882).
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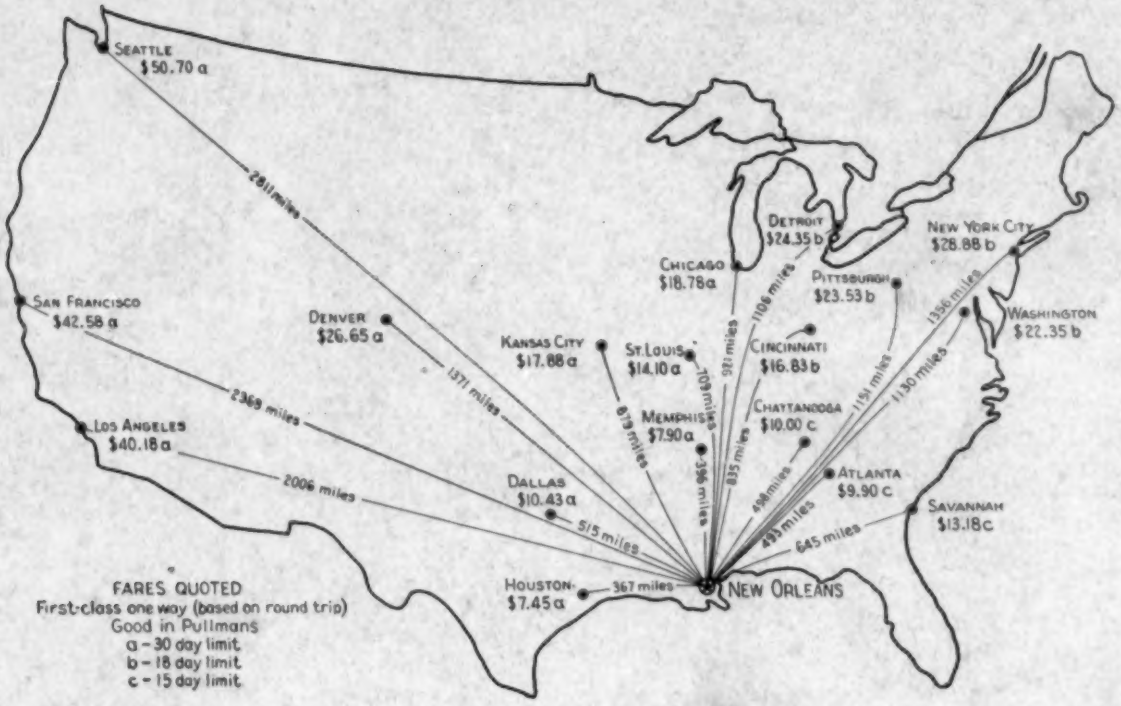

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